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The Pit River Hydroelectric Power Project

UNUSUAL GEOLOGICAL FORMATION MAKES POSSIBLE THE OPERATION OF A SYSTEM WITHOUT THE NECESSITY OF ARTIFICIAL STORAGE CAPACITY. BY CHARLES W. GEIGER

HYDROELECTRIC development in California continues to advance by leaps and bounds. The Pacific Gas & Electric Co. has just completed construction of the first two plants on its Pit River system in Shasta county and work is proceeding rapidly on the construction of a third. The two completed plants are located on a tributary of the Pit River and are known as Hat Creek, No. 1 and 2, while the plant now under construction will be known as Pit River, No. 1. The latter plant will be equipped with two of the largest generators of their kind in the United States.

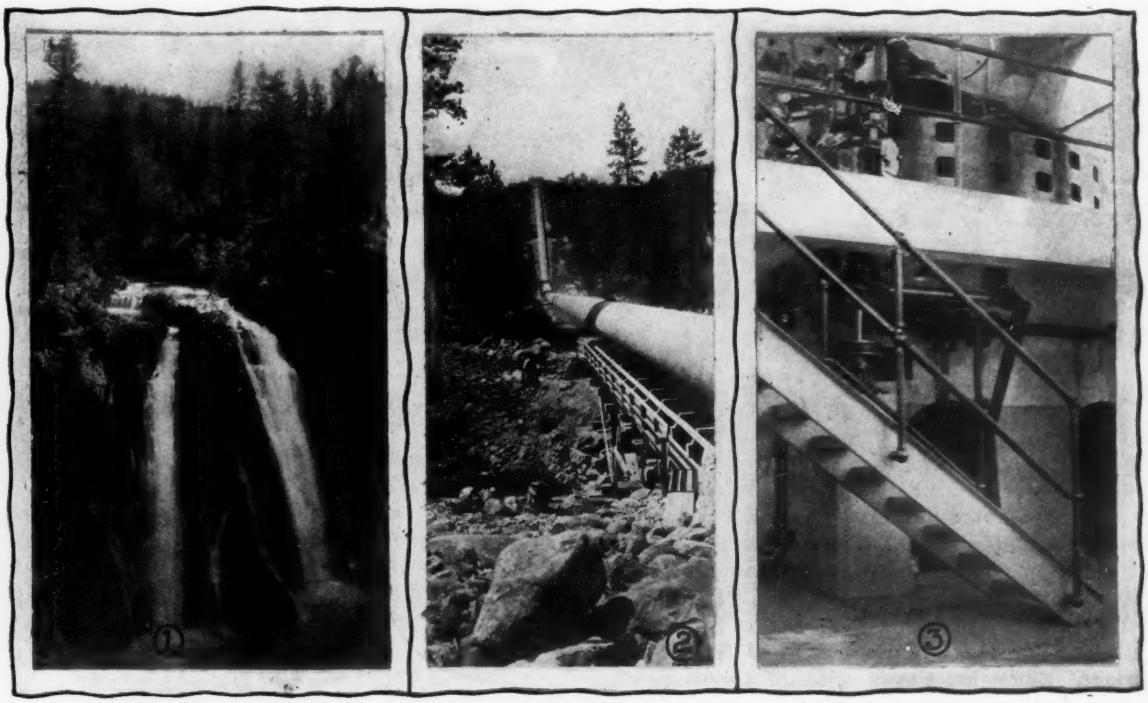


FIG. 1. BURNEY FALLS, SHOWING WATER ISSUING FROM POROUS ROCK. FIG. 2. LOOKING TOWARDS FOREBAY, HAT CREEK PLANT NO. 1. FIG. 3. GENERATING UNIT AT HAT CREEK PLANT NO. 1

This Pit River development is of almost sensational character by reason of the extraordinary waterpower facilities afforded by the Pit and its tributaries, which derive their source of supply from the Cascade range of mountains. There the lava formation gives the soil a sponge-like character, so that streams appear to spring out of the ground, as it were, while the whole territory acts as an underground reservoir; as a result, wet or dry seasons make little difference to the stream flow, which is not only abundant, but even, throughout the year. It is estimated, for instance, that the Pit River with its tributaries, yields an average stream flow of 2500 cu. ft. per sec. even in the dry season. Its value, therefore, for hydroelectric development is unsurpassed.

Early in 1917 the Pacific Gas & Electric Co. acquired valuable rights on the Pit by purchase from the Mount Shasta Power Corporation, which had already started construction work at what is known as the Big Bend (Fig. 4), where the twists and turns of the Pit River

make available a drop of between 900 and 1000 ft. in a distance of seven miles. The power company's engineers, however, realizing the necessity for immediate development in view of a serious water power shortage which came upon the entire state of California in 1920, recommended moving higher up stream and taking advantage of the abundant flow from the Pit's two most important tributaries, namely, Fall River and Hat Creek, the former contributing 1500 and the latter an average of 600 cu. ft. per sec. to the parent stream. In this way a series of power developments was planned, beginning as stated before, with Hat Creek and ending at the Big Bend. Preliminary work was started about a year ago and since that time construction gangs have worked night and day throughout the entire period in an effort to bring at least the first two of the proposed developments to completion before the close of last summer, the period of the year when, as a rule, there is unusually heavy draft upon the resources of the power companies generally throughout the state.

Flow of Pit River Constant Throughout Year

The fame of the Pit River as an abundant stream of constant flow regardless of climatic conditions and independent of reservoir storage had spread far and wide through the land ever since, in the early part of 1917, the announcement went forth that the Pacific Gas & Electric Co. had purchased from the Mt. Shasta Power Corporation its valuable water rights on the Pit, and that when those water rights had been developed into electric energy, there would be an end, so far as North-central California was concerned, to all fear of power shortage. Since that time a series of dry winters has brought consternation upon the power companies and the industries dependent upon their output. The Railroad Commission of the State of California, having jurisdiction of all public utilities, has found it necessary, through its Power Administrator, to curtail the use of power and to impose conditions as to hours during which the farmer might operate his pumps. In this hour of stress, then, all eyes were turned to the Pit, and in the hearts of all concerned there was general rejoicing when announcement was made, in the late spring of 1920, that surveys had been made, locations for the first available power sites agreed upon, the necessary approval of the Railroad Commission secured and the word given to go ahead.

All that year, the power shortage was more acute than ever in the history of California. In the Sierra Nevada, reservoirs ran low and the water sheds supplying them held no moisture. Under such conditions, the layman, or even the engineer unacquainted with the geological formation of the Cascade region, might be forgiven for taking the optimistic statements concerning the ever-abundant flow of the Pit with a grain of salt. True, the Sacramento River continued to pour several thousand cubic feet per second into the bay of San Francisco, and it was generally known that the Sacramento depended mostly upon the supply of the Pit and McCloud rivers for its message bearing volume; but it really did seem to the average person that the unusual climatic conditions prevailing throughout the state must be reflected even in that wonderful region where it was said rivers sprang out of the ground, coursed through valleys a few feet beneath the surface of the soil and performed other tricks that seemed to trespass upon the laws of nature as evidenced and obeyed in other parts of the country. If there ever was a time for testing the truth of these reports, it was in 1920, and now all that remains to be said upon this point is that the Pit River, with its tributaries, stood the test nobly and all during the dry summer months carried sufficient water oceanward to substantiate every report upon which the Pacific Gas & Electric Co.'s hydroelectric program in that section of California was based.

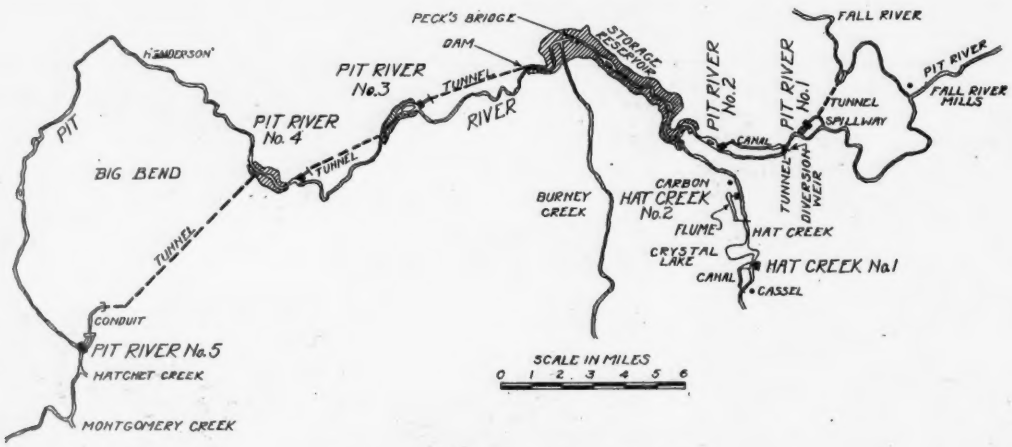


FIG. 4. MAP OF PIT RIVER PROJECT

Regularity of Flow Due to Geological Formation

The extraordinary difference between waterpower conditions in the Cascade region as compared with the region of the Sierra Nevada is one of geological formation. It is just the difference between lava and granite, the latter acting as a cup and the former as a sponge; hence all the underground storage that causes abundant streams to appear to leap out of the ground at will. Striking illustrations of this in the territory covered by the P. G. & E. Co.'s operations are afforded by the Fall River itself, Rising River, Hat Creek and Burney Creek,

all tributaries of the Pit and without whose helpful quotas that stream would be puny indeed.

At this point, it might be well to comment a little upon the geological formation of this water wonderland. According to geologists, this section of northeastern California was originally an area of low elevation, an extension of the Sacramento Valley, in fact, after the Coast Range and the Sierras were formed. Then came the Cascade Range, extending from Washington to Oregon and into northeastern California, and whose southern line, roughly speaking, lies along the north fork of the Feather River. This Cascade Range closed the gap between the Coast Range and the Sierras. Marked by two sentinel peaks, Mt. Shasta and Mt. Lassen, it formed a dam or series of dams across the outlet of what was an extension of the Sacramento Valley into northeastern California and formed the Pit River basin, covering an area of about 5000 sq. mi. Similar dams were formed across several branch streams of the Pit, including Fall River, Rising River, Crystal Lake and Burney Creek. The water falling upon this immense lava plateau largely sinks through the lava, and being cut off from direct outflow by the lava flow across the old stream channels is stored in lava-covered basins and emerges in very large springs, almost perfectly regulated.

Such is the explanation furnished by geologists of the remarkable water conditions of the Pit River basin upon which about 80 per cent of the low flow of the Sacramento River at Red Bluff depends. The Pit has its main source in several large springs which originate east of the summit of the mountains in large underground storage in the lava beds of northeastern California, which are found at the southern end of the Cas-

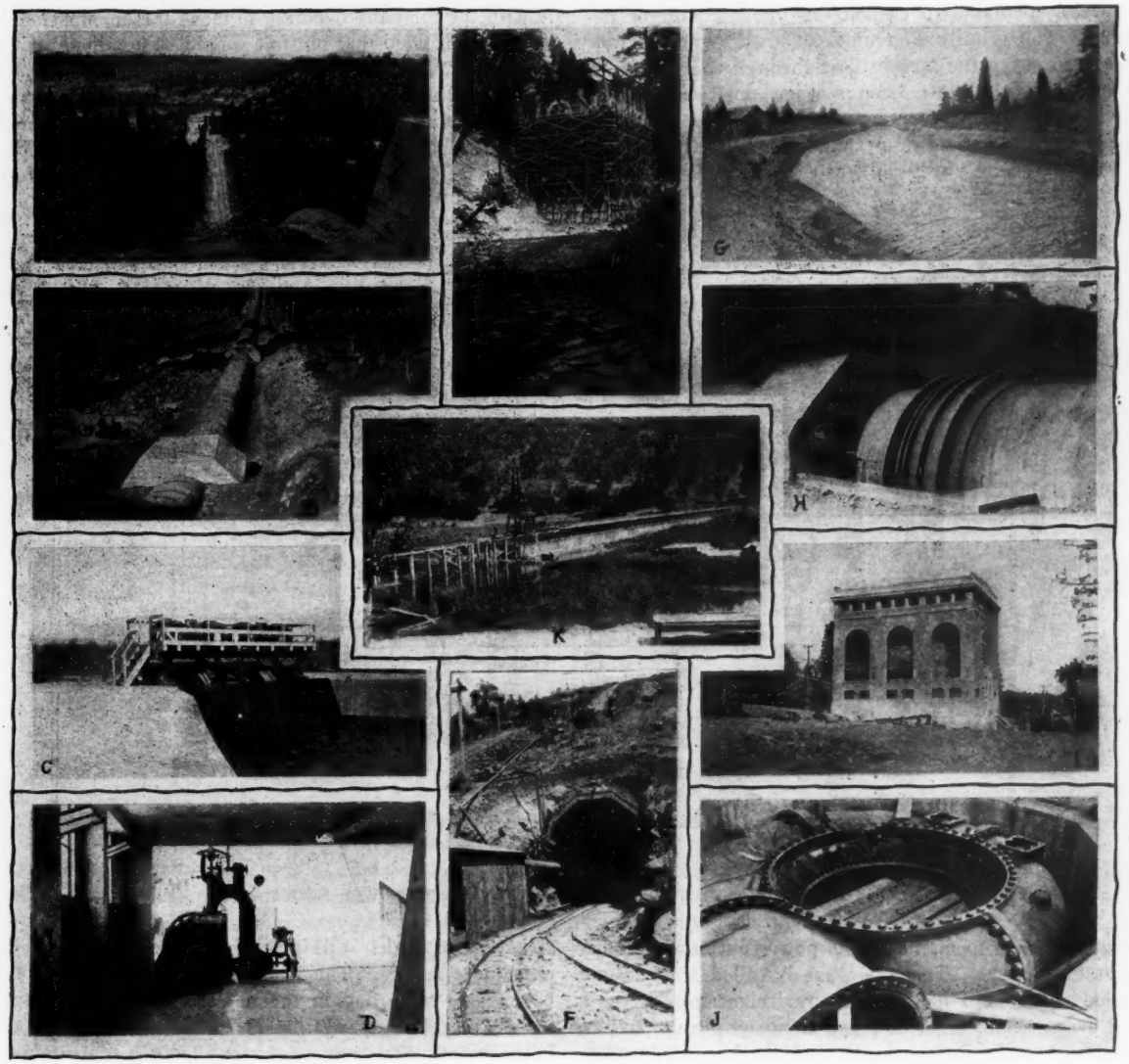


FIG. 5. VIEWS OF PIT RIVER POWER PROJECT. A, HAT CREEK, NO. 1. PRESSURE DROP WITH POWER PLANT IN DISTANCE. B, CONCRETE ANCHORS IN PIPELINE. C, INTAKE GATE STRUCTURE. D, EXCITER UNIT. E, HAT CREEK PLANT, NO. 2, UNDER CONSTRUCTION. F, TUNNEL AT PIT RIVER, NO. 1. G, DIVERSION CANAL, HAT CREEK, NO. 1. H, EXPANSION JOINT IN PIPELINE. I, HAT CREEK, NO. 1, POWER HOUSE. J, TURBINE BEING INSTALLED, HAT CREEK, NO. 1. K, ROCKFILL CRIB DAM

cade Range. These springs originate at elevations of about 3220 to 3350 ft. above sea level. They have practically a constant flow the year round (there never being floods as known in other parts of the country) an average in the aggregate of about 2500 cu. ft. per sec. The daily flow from these springs totals about 5000 acre ft. and supplies every year during the ordinary low-water season more than a million acre feet of water. Usually the water supply for a California power plant has to be estimated and calculated for different previous years in order to obtain anything like an accurate idea of the water available for which the plant should be designed. The granite Sierra streams all require water storage to carry the stream flow through the low-water season and full draft from storage must usually be provided for about five months in order to assure a supply for the low-water period. The Pit River water sources are entirely different, as there is already understream, at the Big Bend. It is a tunnel proposition and takes advantages of the twists and turns of the Pit River which give a drop of between 900 and 1000 ft. in 7 mi.

The Old Mt. Shasta Power Corporation actually started work on this, but abandoned it for want of means to carry the project to completion. Then, when the P. G. & E. Co. secured the water rights, work was resumed; but it is a job of several years and involves an expenditure of something like $19,000,000.

The former consideration, no doubt, had much to do with the company deciding to move farther upstream, for it was decided that no time should be lost in securing relief for their power consumers against the caprices of the California climate. Then, again, why not go farther upstream? The rights are the company's and in the stretch of stream between Fall River and the Big Bend there is a string of possible power sites, the con-

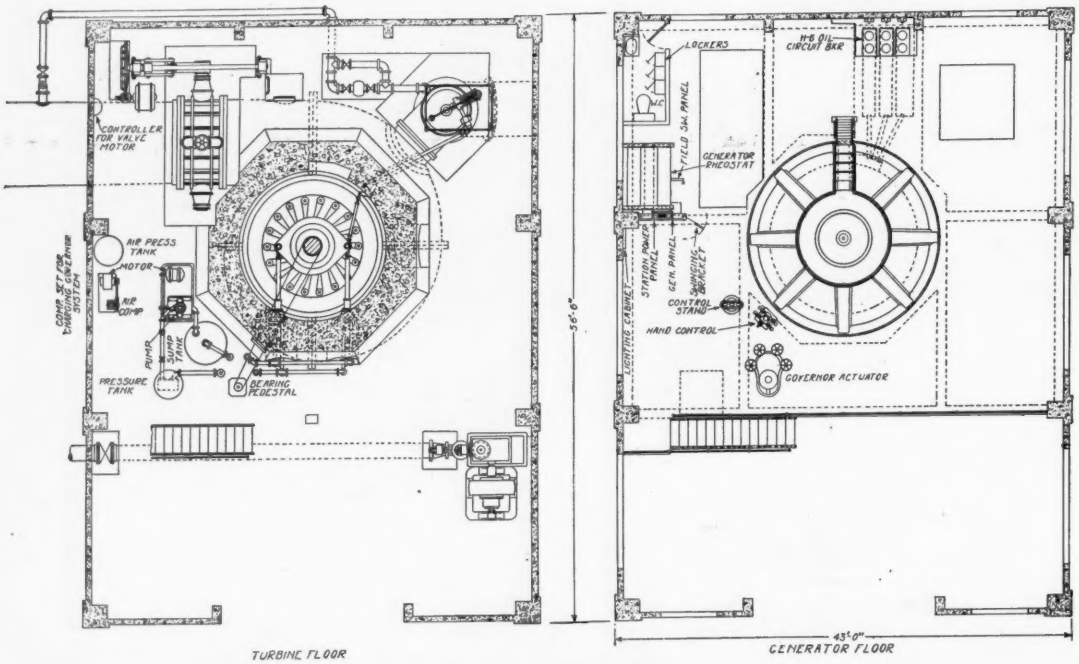


FIG. 6. ARRANGEMENT OF APPARATUS IN HAT CREEK POWER HOUSE, NO. 1

ground storage to maintain the power output at almost constant amount. There is what is called a low-water period of about 4 mo., caused by irrigation, diversion and evaporation, but this plays an insignificant part in the grand total. Before the P. G. & E. Engineers undertook final recommendations they took current meter measurements at various points, these measurements extending from 1901 to 1917. The results of these tests are shown in the table.

It will be observed from the table that the difference between maximum and minimum flows in these streams is unusually slight, so that the mean flow is of considerable volume.

The power plants just completed and now under construction are not the original Mt. Shasta power project as presented to the P. G. & E. Co., at the time of the purchase. That project is located farther down

struction of which will provide ample energy for the immediate future. The Big Bend proposition will not run away; some day in the not too far distant future it will be taken up again. It stands as an ace in the hole, so to speak.

Hat Creek power plants Nos. 1 and 2 are located on Hat Creek within a very few miles of that stream's junction with the Pit. Hat Creek rises in the higher levels overshadowed by the Burney mountain. The real Hat Creek, as a matter of fact, is to all intents and purposes a dead river, for such water as it gathers of its own energy out of the ground is used by the farmers of the district for irrigation purposes; it therefore shines with the reflected glory of another body of water, namely, Rising River, which has its origin partly in a lake and the remainder in springs a short distance away. It seems incredible, but in less than 3 mi. be-

tween its source and its junction with Hat Creek it contrives to convert the latter into a power-giving stream of the capacity previously given.

Hat Creek Plant No. 1

Hat Creek power plant No. 1 is located at the junction of Hat Creek and Rock Creek. The penstock consists of a riveted pipe 1700 ft. in length, with a diameter ranging from 10 ft. at the top to 8 ft. at the bottom, having a 7½-ft. turbine inlet. The maximum drop is 216.8 ft. from head water to tail water. The forebay is unusually small, having a capacity of only 12.5 acre ft. The forebay is connected with the diversion dam by means of a ditch 2750 ft. in length. This ditch has a bottom width of 17 ft., a depth of 9.5 ft. and a width at water surface of 45.5 ft.

The water is diverted from the stream by means of a rockfill crib dam, which is carried diagonally across the stream to give a longer spill crest, a spillway 180 ft. long being provided and water control effected by

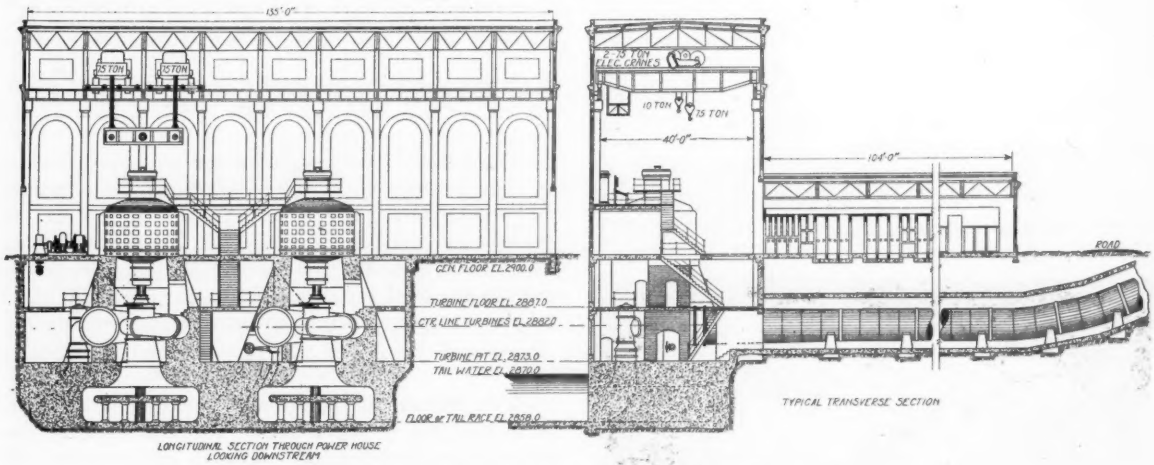


FIG. 7. ELEVATIONS OF PIT RIVER POWER PLANT, NO. 1

Westinghouse air compressor is installed to provide compressed air for actuating the brake shoes in shutting down the generator. By this means, the generator can be brought to a dead stop in a few minutes after water is shut off. Because of the long pipeline, there is a pressure regulator under the turbine capable of discharging 75 to 80 per cent of the maximum flow of water.

The power from this plant is transmitted to Hat Creek Plant No. 2 over a single circuit 6600-v. transmission line, without transformation, the conductors of this line being 500,000 c.m. concentric copper cable. At both ends of the line, suitable lightning arresters have been installed.

Hat Creek Plant No. 2

About two miles lower down stream is located Hat Creek Power Plant No. 2, which was completed in September. The equipment of Hat Creek plants Nos. 1 and 2 are identical with the exception that a bank of 48,000 kv.a. water-cooled transformers wound to operate at 63,500 or 110,000 v. is located at Plant No. 2 for the purpose of raising the generator voltage to 60,000 for transmission over the cross country transmission line already completed between Hat Creek and Cottonwood, 60 mi. away. At that point, the current is delivered to the reconstructed northern California line for transmission farther south. This line voltage will be increased later to 110,000, and finally to 220,000, the highest voltage in the world.

By the time Hat Creek flow has reached Power Plant No. 2 it has passed through Crystal Lake Ranch and has been reinforced by the water from Crystal Lake, as well as some springs which contribute an additional total of about 50 sec. ft., thus providing more power at Power Plant No. 2, where under an effective head of 195.8 ft. and a normal flow of 600 sec. ft. 8630 kw. will be developed. With maximum flow of 800 ft. and an effective head of 194.5 the maximum power which will be developed is 11,200 kw.

The point of diversion for Power Plant No. 2 is above Hat Creek Falls, the diversion consisting of a pile and timber structure placed diagonally across the stream.

steel radial gates 11 ft. by 10 ft. Each of the radial gates is connected to an electric motor by means of chains and worm gear and the gates can be operated from the power house by means of remote control if desired. Hand wheels are also provided on the shaft for hand operation. A screen consisting of steel bars, which can be easily removed, is provided.

The power house is constructed with self-contained steel frame, reinforced concrete walls and roof, 40 ft. by 60 ft. and two stories in height. The turbine setting has a straight conical draft tube, the entire installation being simple and having an exceptional neat appearance.

The power house contains one 15,000-hp. 225-r.p.m. vertical turbine of the Wellman Seaver Morgan manufacture, direct connected to a 12,500-kv.a. General Electric generator. This unit will develop 6650 kw. with 450 sec. ft. of flow, the effective head for this condition being 212.8 ft. The turbine was designed for 450 sec. ft. normal flow and 600 ft. maximum flow. With maximum flow under an effective head of 210.5 ft. 9300 kw. will be developed. The generator is excited by a separate 250-v. exciter, located on the turbine floor, and driven by a 175-hp. Pelton water wheel. A special

The spillway is 282 ft. in length. At this point the course of Hat Creek lies through a small canyon edged by lava beds. The water for Power Plant No. 2 is conveyed down the canyon by a timber flume 4469 ft. in length, 16 ft. 3½ in. by 7 ft. deep, capable of carrying 800 cu. ft. per sec. at the grade of 0.7 ft. per 1000 ft. The forebay is lined with concrete and is equipped with electrically or hand operated radial gates similar to those at Plant No. 1. A riveted steel penstock approximately the same size as the penstock used at Power Plant No. 1 and 400 ft. in length carries the water from the forebay to the turbine. Due to the very short line of penstock at No. 2, the pressure regulator and stop valve in the penstock are omitted.

Pit River Plant No. 1

The diversion dam for Pit River Plant No. 1 is on Fall River, about three-quarters of a mile above Fall River Mills. Storage is not provided and the whole minimum flow of the river will be diverted through 1150 ft. of open cut and 10,160 ft. of tunnel, terminating in a combined surge chamber and spillway. The tunnel will have an area of approximately 154 sq. ft. and be constructed on a grade of 3 ft. per 1000 ft., having a capacity of 1800 cu. ft. per sec. In general, the tunnel will be of horseshoe section, concrete lined, 14.3 ft. high and 11 ft. wide at the bottom.

The two penstocks leading to the plant will be a combination of riveted and lap welded steel pipe 1400 ft. long, with diameters running from 11 to 9 ft.

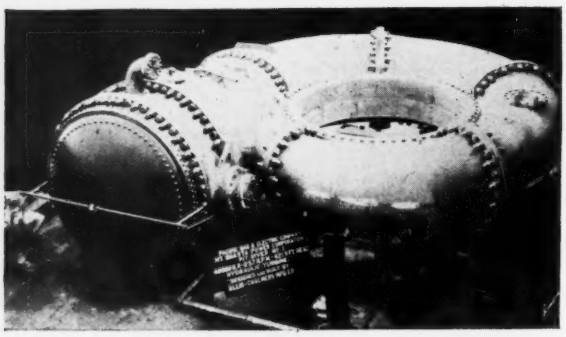


FIG. 8. CASING OF PIT RIVER PLANT TURBINE UNDER TEST AT FACTORY

The two vertical water wheel generators for this plant are the largest of their kind in the United States, being rated at 35,000 kv.a. 90 per cent power factor, 3-phase, 60-cycle, 11,000 v. at 257 r.p.m. The water wheels consist of two 40,000-hp. single runner, vertical shaft, hydraulic turbines. The generators, turbines and accessories were supplied by the Allis Chalmers Manufacturing Co.

The design and construction of the equipment has been dominated by consideration of simplicity, ruggedness, accessibility and durability of material employed, in order to secure maximum dependability and freedom from shutdowns.

Each unit is equipped with cast steel spiral casing, having a nominal inside diameter at the inlet of not less than 78 in. and a flared section at the end for the purpose of connecting to the butterfly valve of 108 in. inside diameter.

The speed ring is cast integral with the casing. This design avails the weaknesses of joints which inevitably results from the use of a spiral casing with separate speed ring under this head and of this large size. The shape of the guide vanes are such that the guide vane mechanism will be balanced at approximately ⅓ gate opening, and they will drift toward this position when detached from the shafting. The braking mechanism is of such capacity that the unit may be stopped within five minutes after the gates have been closed when the turbine is running at normal speed. The brakes are operated by compressed air.

CURRENT METER MEASUREMENTS AT VARIOUS POINTS ON PIT RIVER PROJECT

Location	Maximum Flow Sec - Ft	Minimum Flow Sec - Ft
Fall River at Fall River Mills	1543	1280
Hat Creek at Crystal Lake Ranch and Carbon	701	563
Rising River above Cassel	655	312
Crystal Lake at Crystal Lake Ranch	201	155
Burney Creek Below Burney Falls	246	146

The generators are so arranged as to take air from the power house at the top and bottom of the generator and discharge the hot air into a sheet steel duct. The exciters are rated at 225 kw., 250-v., 257 r.p.m., which is of sufficient capacity to provide field excitation throughout the range of the generator load up to 40,000 kw. at 90 per cent power factor, with 25 per cent margin.

Governing Mechanism

The motion of the flyballs from the floating collar is transmitted to the governor floating lever by means of levers and connecting rods, an arrangement which eliminates irregular or jerky motion usual with the ordinary arrangement of flyball drive consisting of gears or belts.

The regulating valve is of the double-acting type of such a size that oil can be passed through to the regulating cylinders for operating the turbine gates in 2½ sec.

The motion of the valves is controlled through a pilot valve located adjacent to the regulating valve. Both the pilot and regulating valves are completely balanced so that very little energy is required for their operation by the floating lever. This design, together with the high sensitiveness of the flyballs, insures maximum sensitiveness for speed variations, which permits of gate adjustments for minimum changes of load.

Relay Compensating Device

This is of the improved double floating lever principle which allows of great stability of speed regulation within very close range with entire elimination of any hunting or racing tendency, which causes so much wear and tear of the gate rigging.

The ratio of speed variation between no load and full load can be adjusted from 6 per cent to as small a variation as is suitable for commercial speed regula-

tion. If not running in parallel, it can be set for absolutely constant speed.

Synchronizing Attachment for Switchboard Control

This device consists of a d.c. motor mounted on brackets and attached to the governor stand and operates the floating lever by means of belted and geared connection. By means of this device, the machinery can be paralleled or its load adjusted from the switchboard.

The casing which supports the floating lever and compensating dash pot is mounted on cast-iron stand. This stand also contains the regulating valve. The stand and hand operating mechanism is mounted on a cast iron base which is grouted into the concrete foundation.

Pumping System

There is one 80-gal. per min. geared pump for each governor, directly connected to a 15-hp. induction motor. The two pumps are mounted near each other and connected to one impulse wheel so that the impulse wheel may drive either pump.

There are complete tanks for each unit approximately 36 in. in diameter and 10 ft. high.

The piping between the pumps, tanks, operating cylinders and governor stands are of cold drawn seamless steel tubing, and is so arranged that each governor system may be operated independently of the other. Interconnecting piping is arranged, however, so that one pump may supply pressure to both main units.

Each governing unit will have a capacity of 75,000 ft. lb. operating under a pressure of 150 lb. per sq. in.

For the purpose of supplying compressed air, there is a motor-driven air compressor of 8 cu. ft. free air per min. capacity, with a cylinder size 3 in. by 3½ in. driven by a 3-hp. induction motor.

Butterfly Valves

There are two 108-in. cast steel butterfly valves, electrically and hand operated, each valve being designed for a test pressure of 300 lb. per sq. in. and for closing against full working head of 431.5 ft.

The valve body is made of rigid construction to withstand the tension due to the internal pressure, and also the deformation caused by closing the disc tight, and against full pipe line pressure in case of accident on the down stream portion of penstock.

The hand operating mechanism consists of screw and worm gearing supported in a stand and operated from a hand wheel.

The motor operating attachment consists of an extension of the mechanical operating stand to which the electric motor is bolted. Jaw clutches are provided so that the motor may be thrown in or out as may be desired. The clutches are tied together so that the motor attachment and the hand wheel attachment cannot be in mesh with the operating worm gear at the same time, but is so arranged that under no conditions will the operating lever be set free and allow the gate to take its own position.

Future Developments

Near the junction of Hat Creek and Pit River another power house site has been marked for later development. This is below the Pit River canyon and the head is but 125 ft., but when constructed this plant will contribute an average of 15,000 hp. to the total. This development will be called Pit River No. 2. Possibly, however, the next development to be taken up after Pit River No. 1, will be a development below Peck's Bridge. At that point, the Pit River has been reinforced by Hat Creek, Burney and other springs of minor importance, so that its average flow exceeds 2500 cu. ft. per sec. The exact site for the first plant below Peck's Bridge has not yet been chosen. It is to be a tunnel proposition and geological formation will have a lot to do with the decision; but according to the company's engineers' estimates an additional 100,000 hp. of electric energy awaits development there, and so it stands marked upon the construction program to be taken up in the regular order of things as occasion shall require.

The Pacific Gas & Electric Co. contemplates the full development in the basin from a point on Fall River above Fall River Mills to a point on the Pit below the "Big Bend," a distance along the streams of 60 mi. The total fall is 2104 ft., of which it is expected to utilize 2074 ft. in at least five plants. The total continuous power is computed at 320,000 kw. requiring an installed capacity of upwards of 450,000 kv.a.

Hat Creek Plants No. 1 and No. 2, together with Pit River Plant No. 1, which will be in operation next summer, gave the Pacific Gas & Electric Co. about 20,000 hp. average last year from the Pit region, and this year the average will be about 80,000 hp.

Possession by the Pacific Gas & Electric Co. of Pit River and the starting of this project is due to the vision of Frank G. Baum, consulting hydroelectric engineer for the P. G. & E. Co., and the work is going on under his immediate supervision.

The bureau of mines, through a co-operative agreement with the Pennsylvania Geological Survey, has exercised general supervision of the sampling of a large number of coal mines in western Pennsylvania and has also analyzed the samples. Under similar agreement with the Sewalls Point Coal Exchange, about 100 mines along the line of the Virginian Railway have been sampled by engineers under the direction of the bureau.

In the State of Tennessee, through a co-operative agreement with the State Geological Survey, the sampling of coal mines by an engineer of the Bureau of Mines has begun.

Co-operative sampling has also been done in the State of Virginia, the samples being taken by the state geologist under the bureau's regulations and analyzed by the bureau's chemists.

The work of coal sampling and analysis by states is being continued. Large numbers of samples have recently been taken at mines in Virginia, West Virginia, western Pennsylvania, Alabama, Tennessee, Oklahoma, Utah, and fewer in Colorado, Illinois, and Indiana. Data on the coals of Kentucky have been prepared for publication, and will constitute the second report of the series of technical papers containing analyses of coals by states; the first, on Iowa coals, was issued some time ago.

"Do not turn back when you are just at the goal."

Effect of Coal on Excess Air in Boiler Operation

Considerations to be Taken Into Account in Interpreting CO_2 Values with Different Kinds of Coal. By Hugh R. Carr

IN MOST of our up-to-date power plants, and also in the more progressive industrial plants, it is practice to make a continuous analysis of the flue gas with a recording CO_2 analyzer or to analyze at the end of each day a sample taken continuously during the day, or both. Such a daily record is expected to give a comparison of the handling of the fires from day to day. How much is this comparison worth? Suppose, for example, that a plant uses coal from two different sources, say from two different mines in Colorado, the coals having analysis shown in the table.

ANALYSES OF COAL FROM TWO DIFFERENT MINES IN COLORADO

		Coal No. 1	Coal No. 2
Sulphur	per cent	.25	.74
Hydrogen	per cent	5.93	5.30
Carbon	per cent	56.38	72.61
Oxygen	per cent	30.60	9.72
Ash	per cent	5.76	10.39
Heat Value,	B T U	11,900	13,650
Moisture,	as fired, per cent	14.00	3.50

The average CO_2 analysis is found to be 11 per cent for a time, but suddenly falls to 10.5 per cent. The natural thing to suspect is that the firemen are neglecting their fires and that they let the fuel bed become full of holes. They would be unjustly blamed if the No. 1 coal had run out of the bunkers and some of the No. 2 coal had taken its place. The actual excess air is the same in both cases, the difference being due to the fact that the No. 1 coal contained much more oxygen not in moisture than did the No. 2 coal. The actual air required is therefore relatively less with the No. 1 than with the No. 2. The sample taken for flue gas analysis is taken over water and the moisture formed in combustion as well as the sulphur dioxide formed are absorbed by this water. The oxygen in the coal is not taken account of in determining the excess air from the flue gas analysis in the usual manner. Therefore the CO_2 in the flue gas refers only to the oxygen or air required for the combustion of the carbon. In order to make a suitable correction which can be applied in a simple manner, the writer has derived a factor in the following manner:

Let—

v = per cent excess air to burn carbon only

x = per cent of theoretical air required to burn carbon only

$x = v + 1$ or $v = x - 1$

z = per cent of actual excess air

y = per cent of theoretical air required $= z + 1$

S = air required to burn per cent of sulphur in the coal

H = air required to burn per cent of hydrogen in the coal

C = air required to burn per cent of carbon in the coal

O = the oxygen in the coal expressed as air.

The actual air used to burn a pound of coal, the S, H and O, do not show up the flue gas analysis and must therefore be considered as burning with zero per cent excess air, $= xC + (S + H - O)$.

The theoretical air required to burn the coal $= C + H + S - O$.

Therefore, $$y = \frac{xC + (S + H - O)}{C + H + S - O}$$

or,

$$xC + (S + H - O) = y\,(C + S + H - O) = C + (S + H - O) + z(C + S + H - O)$$

and,

$$xC - C = z(C + S + H - O) = C(x - 1) = vC$$

hence, $z/v = C/(C + S + H - O) =$ a constant which may be called the "excess air factor," or z = v multiplied by the "excess air factor."

By using the excess air factor, where no carbon monoxide is found, or is in small enough quantity to be neglected, the actual excess can easily be found from the per cent CO_2 present in the flue gas.

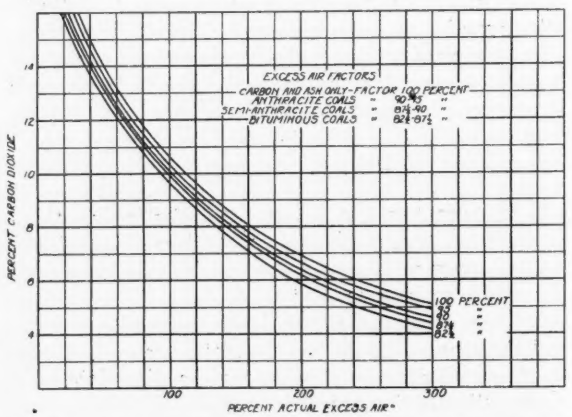


FIG. 1. CHART SHOWING VARIATION IN CO_2 WHICH MAY BE EXPECTED FOR DIFFERENT COALS

It is evident that a coal which consisted of carbon and ash only would have an excess air factor of unity. The curve marked 100 per cent in the chart, Fig. 1, is one for such a coal. No such coal is known, but it is easy to compute and plot its curve and thus later plot the curves of factors less than 100 per cent. The writer has found that the factor for anthracite coal is about 90 to 95 per cent, for semi-anthracite 87.5 to 90 per cent, and 82.5 to 87.5 per cent for bituminous coal. Some far western coals, however, are of such composition as to have factors almost as low as 80 per cent. The eastern coals of the semi-anthracite and bituminous varieties

are generally above 85 per cent. The curves plotted for factors less than 10 per cent show fully the rise or fall in CO_2 which may be expected when a change in coal is made if the excellence in firing conditions remains the same. In plotting these curves the nitrogen in the coal has been neglected as being insignificant as compared to the nitrogen in the flue gas. The nitrogen, even from high nitrogen coal, is never more than ½ of one per cent of the nitrogen in the flue gas.

In the algebraic derivation above the excess air factor was found to be $C/(C + S + H - O.)$ If the percentage of carbon, hydrogen, sulphur and oxygen in the coal are expressed as small letters c, s, h and o, the excess air factor equals $11.6c/(11.6c + 34.8h + 4.35s - 4.35o)$, or if simplified equals $c/(c + 3h + .375s - .375o)$. The ultimate analysis is, of course, necessary for determination of the excess air factor from this formula.

It is not always possible to procure an ultimate analysis of the various coals which one uses and the writer has found it necessary to work out a fairly accurate formula for getting the factor from the proximate analysis which is nearly always available. This formula is derived in part from the curves of Prof. L. S. Marks and in part from observations of the writer. If F equals the per cent fixed carbon, V the per cent volatile matter, and S the per cent sulphur (separate determination) in the coal:

The excess air factor =

$$\frac{F+.9\,[(100V\div F+V)-14]-S+(\text{MOISTURE}\div 2)}{F+1.235\,[(100V\div F+V)-14]+(245V\div F+11V)-.375V-.625S}$$

It can be seen that the sulphur value can be left out without much error, but if the sulphur content has been determined it should be used. The formula shown above is approximated for bituminous coal.

It does not necessarily follow that just changing the grade of coal will cause a change in flue gas consumption which may be predetermined from the analysis of the coal. The coal to which the change is made may be of such character as so to improve the firing conditions that the flue gas analysis shows no change, but there is a corresponding fall in the excess air. Even this is no proof that such a coal is more economical than the coal it replaced. Many coals which have a low excess air factor are very high in moisture and, although they may make very efficient fuel beds, the high moisture content may be enough more than to offset the gain due to decreased excess air. The excess air factor is a criterion of the efficiency of the firemen to a great extent, but it is not a criterion of the efficiency of the coal. The two Colorado coals mentioned above are an example which will illustrate the point.

If the CO_2 percentage had risen one per cent when No. 2 coal replaced No. 1 coal, the excess air would have been decreased 14 per cent and 0.03 lb. of air more is required per thousand B.t.u. produced. There would also be less moisture to be heated up to chimney temperature, although it is very hard to determine whether this moisture would be enough to offset the additional air. In order to have some simple method of determining the relative value of the coals the writer has developed a chart which can be used for the purpose. In using this chart it is necessary to know the total amount of moisture in the coal and that formed by the combustion.

By the ultimate analysis, the moisture produced per pound of coal is equal to nine times the hydrogen in the coal.

By the proximate analysis, the moisture produced per pound of coal is equal to free moisture $+(588\,V \div F + 11\,V)$, this approximation being for bituminous coal only.

The curves plotted are very useful in determining the relative value of the coal. As this value differs according to the per cent of excess air, the expected average CO_2 must be assumed; in fact, it can be pretty well checked up by using the excess air factor as outlined above if one coal is in use. The CO_2 having been

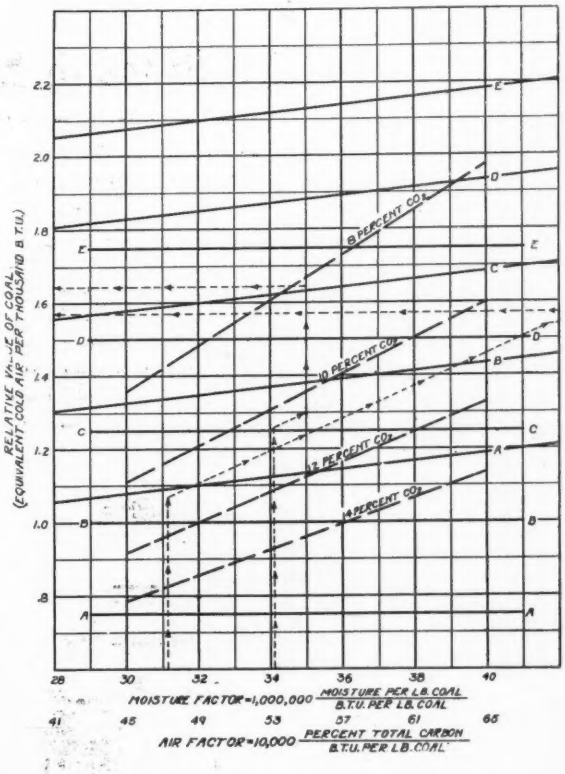


FIG. 2. CHART GIVING THE RELATIVE VALUES OF DIFFERENT COALS FOR VARIOUS VALUES OF CO_2

decided upon, the two values which vary with the coal must be determined before the chart can be used. They are: 10,000 × per cent of total carbon ÷ B.t.u. per pound of coal, and 1,000,000 × total moisture per pound of coal ÷ B.t.u. per pound of coal. The factors of ten thousand and one million are used to make the scales on the chart easy to handle.

The value for the total carbon can be taken from the ultimate analysis of the coal if it is available, or approximated from Prof. Marks' curves which may be expressed by the formula, total carbon equals $F + .9\,(100\,V \div V + F) - 12.6$ from the proximate analysis.

As an example of the use of this chart the coals mentioned before in this discussion can well be used:

Number 1 coal; From previous discussion CO_2

assumed average 11 per cent, then the carbon factor

$$\frac{10{,}000 \times \text{per cent total carbon}}{\text{B.t.u. per pound coal}} = 47.3,$$

and the moisture factor

$$\frac{1{,}000{,}000 \times \text{total moisture per pound coal}}{\text{B.t.u. per pound of coal}} = 44.8$$

From the chart the relative value is 1.57.

Likewise with number 2 coal the carbon factor is 53.2 and the moisture factor is 35.0, and the relative value is 1.645. As in previous discussion, the CO_2 is 10.5 per cent in this case. The procedure in using the chart in this case is as follows: Start at 53.2 on the carbon scale and go up to the 10.5 per cent CO_2 line, then turn parallel to the CO_2 line until the moisture line at 35. is reached; follow this line to the same relative distance above the upper reference line c as the first turning point is above the lower reference line c. At this point, turn left and read the relative value on the scale.

The chart can also be used backward to advantage. For example, one wants to find out how much firing conditions must be bettered in order to bring No. 2 coal on a par with No. 1. This is found to be the point of 11 per cent CO_2 for No. 2 coal also. From the excess air factor curves it can be seen that the excess air must be reduced from about 88 to 80 per cent.

Considerable money can be saved by a little thought on the matter of the coal one uses in his plant and the intelligent use of data such as has been outlined above should add to any engineer's reputation as an engineer.

Heat Balance in Steam Power Plants

Particulars of Systems Employed in Three Large Modern Stations

MUCH has been written concerning the design of power-generating equipment, combustion methods, and general design of power stations. Comparatively little, however, has been said concerning the heat balances that have been secured, and that may be secured in steam power plants. By heat balance, we are here to understand that correlation of events in the heat cycle of the plant as a whole which adjusts the rate of steam generation to the demand with the least possible waste of heat, and the least possible expenditure of coal.

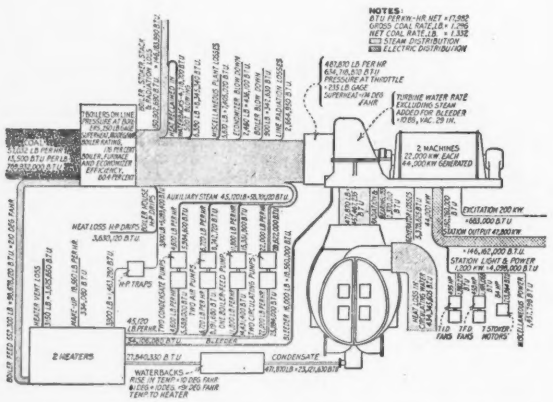


FIG. 1. HEAT BALANCE AT MOST ECONOMICAL LOAD

There are four principal sources of heat waste with which the power plant designer has to deal: 1, radiation. 2, stack losses. 3, losses in condensing water. 4, losses due to excess exhaust steam. The means which he employs to reduce these losses determine the heat balance to be secured in the operation of the plant.

For the purpose of starting a general discussion on this broad subject, there were presented before the Power Division of the American Society of Mechanical Engineers at the 1921 annual meeting held at New York City, December 5 to 9, a number of papers on the subject of heat balance.

While the systems described in following abstracts of these papers are those used in large stations, the ideas contained in them might well be applied to stations of moderate size.

Heat Balance at the Delaware Station of the Philadelphia Electric Co.

THE SYSTEM of heat balance and the auxiliary system in use at the Delaware Station was described by E. L. Hopping. In working out the system, the factor of reliability of service was considered of prime importance, and of somewhat greater value than that of heat economy. It has always been considered by the company that the small comparative cost of duplicating the main generating unit auxiliaries is fully warranted in view of the resulting ability to keep a large unit on the line in case of failure of any of the different auxiliaries connected with the unit. Duplicate auxiliaries were therefore installed throughout. The next step was to settle upon the method of driving them. Enough steam driven auxiliaries were selected to furnish the required amount of exhaust steam necessary to heat the feed water under varying conditions of vacuum. Turbine drive was installed on each of the duplicate auxiliary pumps connected with the main generating units, together with turbine drive on boiler feed pumps and on one house pump.

It was, however, found necessary at times of heavy load and high vacuum to supply a certain additional amount of heat, which was obtained by bleeding the main turbine at the eleventh stage.

The forced and induced-draft fans and the stokers are motor-driven and receive their current through a station light and power system. On each of the main units one of the two circulating pumps is installed with a duplex (steam and motor) drive. By use of this type of drive two results are obtained:

1. A flexible unit is available, which will supply the required heat variation for maintaining a practically constant feed water temperature. 2. In case of trouble on either the steam supply or the electric service,

the opposite drive will automatically pick up the load, and thus keep the condenser water in circulation.

For air and condensate pumps, a duplex drive is not deemed necessary, as, in case of trouble with either of these auxiliaries, a brief shutdown would not be serious.

Two heat-distribution diagrams have been worked out, based on the present installation of two 30,000-kw. generating units. Figure 1 illustrates the heat distribution for an hourly load at the most economical point of operation for the turbine, and with a vacuum of 29 in.

The overall efficiency of the boiler, stoker and economizer of 80.4 per cent, given on Fig. 1, is based on an actual test made during the month of June, 1921, when an efficiency of 81.7 per cent at a boiler rating of 176 per cent was obtained. A correction has been made on this diagram for the lower air temperature that would prevail during the winter months, at which time a vacuum of 29 in. is obtainable.

Under "heater vent losses" has been included a loss of about 5 per cent of the exhaust steam used for feed water heating. This loss would be difficult to measure with any accuracy, but it is believed from rough checks on heat absorbed in feed water that the figure of 5 per cent should cover the losses at this point.

The item of line radiation losses, while apparently small, is noted separately, due to the fact that this is a heat loss only. When the original heat balance was figured for this plant, it was felt that it would never be necessary to bleed the turbine, due to the fact that a large increase in temperature of the condensate was expected as a result of passing the condensate through the waterbacks in the boiler bridge walls. It was found, however, in actual practice that, due to the very large combustion chamber and the more complete combustion secured therefrom, the temperature rise of the water was almost one-third less than that originally estimated.

The heat distribution for the hourly condition (Fig. 1) does not, of course, make any allowances for banking or emptying of boilers for repairs. These are about the only losses which would occur over continued operation, which is not included in this diagram.

Figure 2 illustrates the actual heat distribution over a period of one week, during April, 1921. It will be noted on this diagram that the load factor of the plant, based on its maximum capacity, was only slightly over 50 per cent, which means, in this case, that the average boiler efficiency is lower, and the average turbine water rate higher, than will be obtained under more favorable load conditions.

There are several items on this diagram which differ from the diagram in Fig. 1, as follows:

(a) A considerable difference will be noted between the heat value of the coal as used in this diagram and that used in Fig. 1. The coal was comparatively high in heat value during this week's operation, whereas the average over a longer period would be lower.

(b) All of the turbine-driven condenser auxiliaries have been grouped, as the number of auxiliaries used in varying conditions necessarily varies with the load and temperature.

(c) The station light and power load has also been given as one item, due to the fact that the number of auxiliaries in service at various times depends on the load and temperature.

(d) There is no temperature increase shown in the condensate between the condenser and the heaters, as the waterbacks had not been connected to operate on condensate at that time.

(e) The average boiler-feed temperature at this time (for the diagram in Fig. 2) was 204 deg. F.

Throughout the week illustrated in this diagram there were six boilers on the line, with the exception that over the week end, when the station load is usually low enough to be carried on one turbine, one boiler was taken out for repairs and cleaning. The banking hours represent the hours during which certain boilers were banked to take care of low-load conditions between midnight and 6:00 a. m. It was found more economical to bank boilers for this period than to operate the entire six boilers at a lower rating.

Heat-Balance System for Hell Gate Station

The Hell Gate Station of the United Electric Light and Power Co., now being built in New York City, will have an ultimate capacity of 280,000 kw. The initial installation of two 35,000-kw. single cylinder units and

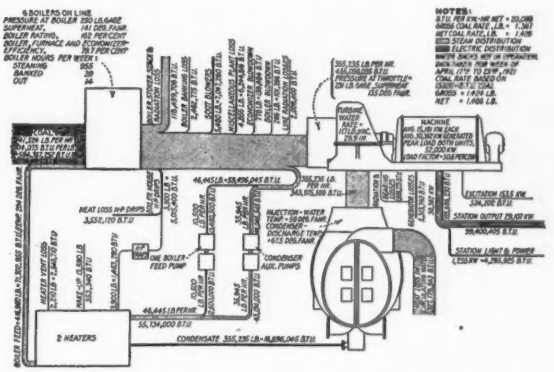


FIG. 2. HEAT BALANCE FOR ONE WEEK'S OPERATION

two 35,000-kw. double cylinder units is now being completed. The heat balance system to be used at this station was described by J. H. Lawrence and W. M. Keenan.

The station will be operated as four independent groups, each consisting of one 60-cycle unit, one 25-cycle unit, one house alternator and six boilers, although provisions have been made for interconnecting the various groups electrically and mechanically.

In connection with the design of this station, the following systems for driving the auxiliaries were considered:

All steam; steam and direct current; steam and alternating current; direct current; alternating current. After a careful study had been completed, it was decided to adopt the alternating current system.

All auxiliaries in this station are to be motor-driven, with the exception of one boiler-feed pump for each group, one fire pump and one of the two exciters for each house alternator. One-half the power for the auxiliaries of each group of two main units will be obtained from the main 60-cycle bus and one-half from the house alternator, so that in case of interruption of

either source of power only one-half the auxiliaries will be shut down.

The house alternators will be 2500-kv.a. 60-cycle 3-phase 2300-v. direct-connected non-condensing machines, running at 3600 r.p.m. The power for the auxiliaries from the main station bus will be transformed from 13,200 to 2300 v. by means of two 7500-kw. power banks located in the boiler-house basement. All motors 25 hp. and over are to be operated at 2300 v., excepting the motors for the coal towers, cranes and skip hoist, while motors under 25 hp. will be wound for 220 v.

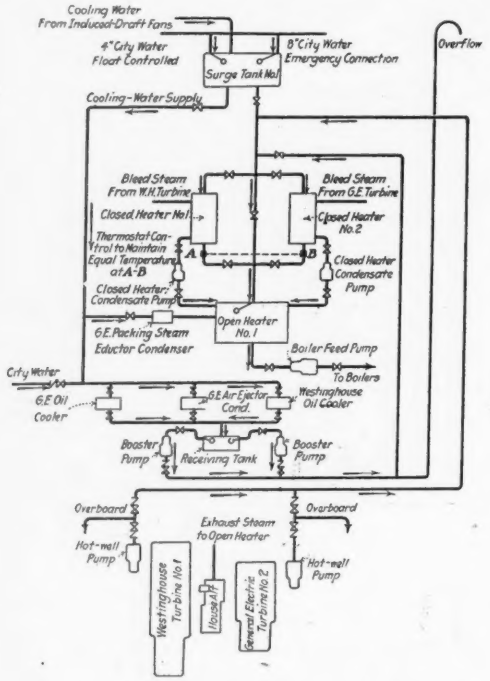


FIG. 3. HEATER CONNECTIONS FOR ONE SECTION

A diagram of the feed water system of one group appears in Fig. 3. The condensate after leaving the condensers goes through closed heaters where it is heated to about 150 deg. F. and then enters the open heaters where it is raised to 210 deg. F. The condensate is then pumped by the boiler-feed pumps direct to the boilers. Thermostatically controlled valves equalize the load on the two closed heaters. The closed heaters are supplied with steam at about 6.5 lb. absolute pressure bled from the lower stages of the main turbines. The condensate from the closed heaters is pumped to the open heater. As indicated in Fig. 3, fresh water obtained from the surge tank is used for the oil coolers and air-ejector condensers and discharges to the inlet of the closed heaters in order to conserve the heat from those different sources.

At the Colfax Station

THE SYSTEM of heat balance employed at the Colfax Station of the Duquesne Light System was described by C. W. Clarke. This station is designed for an ultimate gross capacity of 360,000 kw. and for a maximum output of 300,000 kw. The generating equipment as now planned will consist of six 60,000-kw. turbo-alternators, of which one is now in service and a second in process of installation. A 2000-kw. house turbine is provided to supply auxiliary power. This turbine comprises part of the heat balance system.

Figure 4 shows the bus arrangement for supplying the electric auxiliaries. There are two busses from which the auxiliaries may be supplied, one fed through a transformer bank from the main station bus, the other fed by the house turbine. These two busses are tied together through a motor-generator set, so arranged that energy can pass from the auxiliary bus to the house-turbine bus but not in the opposite direction. A direct tie is provided between these two busses for use in case of failure in the motor-generator connection. The switches in the direct tie and the motor-generator connection are interlocked so that only one can be closed at a time. Auxiliaries are so connected that they may be fed from either bus, the switches being provided with interlocks so that both cannot be closed at the same time.

With the present auxiliary load the auxiliary bus fed from the main station bus is not necessary. The house turbine capacity is ample to carry the entire load. When the second 60,000-kw. unit is installed, however, the auxiliary load will exceed the capacity of one house turbine, resulting in part of this load being placed directly on the auxiliary bus and being fed from the main bus. Only as much load will be thrown on the house turbine bus as is necessary for heat balance.

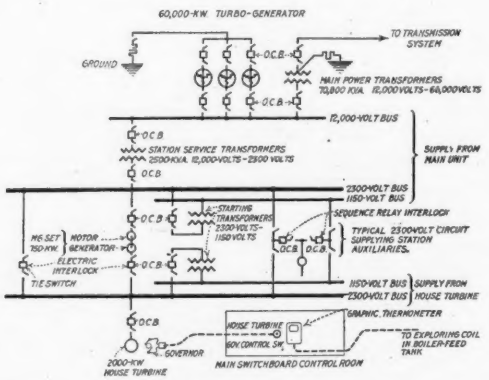


FIG. 4. CIRCUIT DIAGRAM FOR AUXILIARIES AND HEAT CONTROL

For starting purposes an 1100-v. bus is provided, which obviates the necessity for compensators and other starting devices. The starting and running switches are provided with sequence interlocks, which makes it impossible to close the switch on the 2300-v. bus until after the 1100-v. switch has been closed and opened.

Due to the slip in the motor-generator set, the frequency produced by the generator is about 57 cycles when the main bus frequency is 60 cycles. If the speed of the house turbine is varied so as to make its frequency slightly above or below that of the house-turbine bus, the amount of load carried by the house turbine will be correspondingly varied. The system of using a house turbine paralleled on the main bus is not new, but in existing installations of this kind considerable difficulty has been met with, due to differing characteristics of

the small house turbine and the large units supplying the main bus. The motor-generator set mentioned above was introduced into the system to avoid this difficulty. This piece of apparatus acts somewhat like a flexible coupling, taking up the momentary variations in frequency on both sides. This arrangement permits of any desired variation in the quantity of exhaust steam available for heating the feed water since the greater part of the steam for feed heating comes from the house turbine.

The general heat cycle is indicated on the diagram, Fig. 5. As will be seen from this diagram, the condensate passes from the hot well to the double-effect evaporator, where it acts as a circulating medium in the evaporator condenser, absorbing the heat of vaporization from the water evaporated. Thence it goes to a head tank located on the boiler-house roof. This tank merely acts as a small storage reservoir to take care of variations in water flow in this part of the system. Normally, the make-up to replace water losses throughout the system enters the flow at this point as well as returns from the main unit glands and other miscellaneous clean-water returns with the exception of the high and low pressure drips. The water from this tank flows to the barometric condenser. A sufficient quantity of steam is admitted to this condenser, the quantity being controlled as described in the preceding paragraph, to raise the water temperature to that desired for boiler feed.

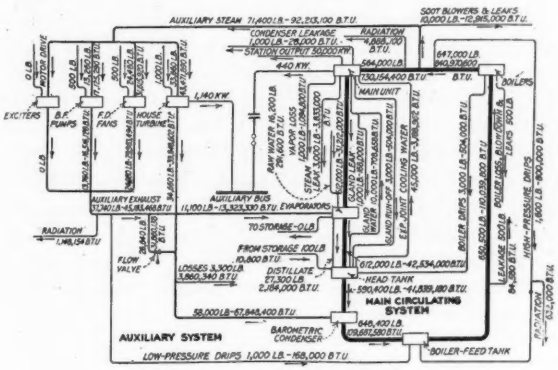


FIG. 5. HEAT FLOW DIAGRAM

High Velocity Steam Mains

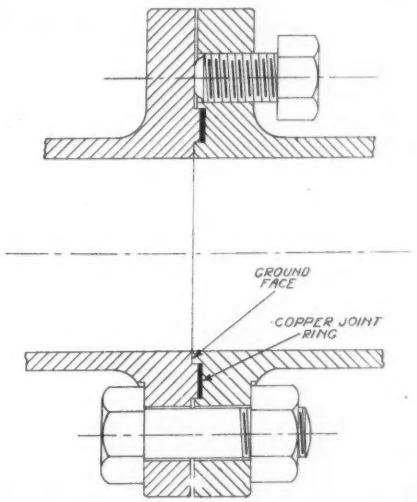
THE USE OF HIGHER VELOCITIES IN STEAM MAINS WILL RESULT IN EFFECTING CONSIDERABLE ECONOMIES. BY CHARLES HURST

IT HAS recently been suggested in various quarters that a gain in steam engine performance could be secured by employing higher steam velocities through the valves than are now customary, resulting in smaller clearances and reduced valve leakage. If this practice were extended to steam mains, considerable advantages and economies would accrue. Up to the time when the steam turbine became the accepted type of prime mover for large units, the practice was to limit the flow of steam in pipes to a speed of about 100 ft. per sec., calculated on the piston displacement of the high pressure cylinder. This was really a mere rule of thumb without any logical or scientific basis, because it took no account of the varying speed of the piston and the point of cutoff. With the advent of the steam turbine the supply mains were calculated for a given pressure drop between boiler and turbine, the Spitzglas formula

$$W = K \sqrt{\frac{p\,w}{h}}$$

being usually employed. This is a rational method of design, and has been fully justified by actual results obtained. It has been customary to allow a drop of from 2 to 5 lb. in calculation of modern plants and it is now suggested that far larger drops be calculated for, say, from 20 to 25 lb. per sq. in.

Taking the case of a 1000-kw. turbo generator with a full load steam consumption of 16 lb. per kw.-hr., the size of supply main, according to present practice, would be about 5 in. for a pipe length of 140 ft., but under the conditions here advocated the main would be only about 2½ in. diameter; and in a new plant the boiler pressure would be raised the extra 20 lb. to give same pressure at the turbine stop valve. At light loads and at starting, the full boiler pressure would accumulate at the turbine stop valve. This would be reduced by a reducing valve immediately after the stop valve. It is also suggested that the inside of the steam mains be polished. By suitable machinery this could be accomplished at very slight extra cost. The following advantages would be gained:



TYPE OF JOINT SUGGESTED FOR USE IN HIGH VELOCITY STEAM LINES.

1. Smaller radiation and conduction losses.
2. Reduced cost of piping, lagging, hangers and pipe supports.
3. Greater elasticity of steam line.
4. Increased superheat at stop valve.
5. Reduced size of boiler.
6. Upkeep on pipe joints reduced.
7. Cooler and lighter power house.

Against these advantages must be set the slightly increased cost of boiler due to heavier pressure, but this would be largely if not entirely offset by item 5. With such high velocities there is some danger of erosion of the ordinary type of valve seats due to the cutting

action of high speed steam. This objection could be overcome by employing a gate form of valve with spring seats, and so arranged that when open the passage was simply a continuance of the smooth pipe bore. The British Hopkinson valve is a notable example of the type. Some erosion is also to be expected at the bends where the direction of the steam is changed, but anyone who has examined a steam turbine at the end of a long run will realize how slight erosion is under very high velocity, and in any case an extra thickness of pipe for bends could be used.

With regard to pipe joints, these should, in the writer's opinion, be of the protected grummet form. The design shown in the illustration is suggested. The difficulty of removing a pipe from the line would be overcome by the great elasticity of a range of small piping, allowing sufficient spring to open out the joint past the grummet projection. Tapping for forcing screws could be provided in each flange joint, as shown, to facilitate opening up. Such a joint would be of so secure and permanent a character that the removal of a pipe to remake a blowing joint would be a rare occurrence.

The suggestion of high velocity mains is particularly applicable to cases where the boiler is a considerable distance from the turbine, as the losses of a long main would be very small. The adoption of high velocities would, in fact, give greater freedom in plant layout, since distance between boiler and turbine would cease to be a vital or relatively important factor.

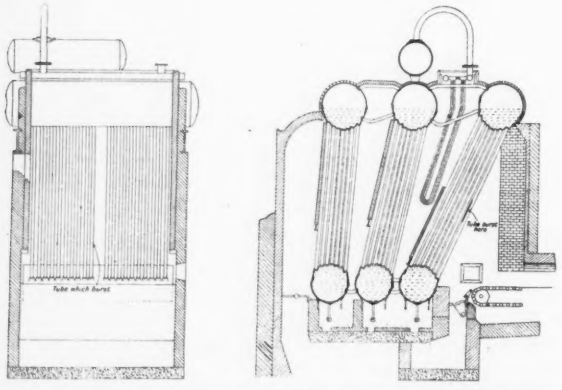
In the case of a reciprocating engine, where the flow in the main is intermittent, it would be advisable to place a small receiver near the engine to equalize the rate of flow in the steam main. The size of pipe would then be calculated exactly as for a turbine, that is on a pound-per-hour and pressure drop basis, and not on piston displacement. The short pipe between the receiver and cylinder would be of the usual present-day proportions, since the flow would be intermittent. Probably a receiver of half the capacity of the high pressure cylinder would be found quite large enough.

It is a well known fact that the barrier to higher steam pressures and temperatures lies not in the boiler or engine, but rather in the connecting link between the two main units of power production. It is time that this barrier be removed and the writer believes that very material advance is open in the direction here indicated, and that if the suggestion were adopted, steam engineering would take a step forward towards both safety and economy.

Notes on British Power Plant Practice

REFUSE AS A FUEL IN BRITISH POWER PLANTS. BY C. H. S. TUPHOLME

FACTORY refuse is being used more generally than ever in British power plants for the generation of steam. In a certain manufactory, for instance, no fuel is being purchased at all, the whole of the works' power plant is driven, and the shops and offices lighted, by utilizing the wood scrap, waste as fuel under the boilers. In this specific instance, the power plant efficiency is just as high as when coal was burnt, and operating costs are naturally very much lower.



ELEVATIONS OF BOILER IN WHICH TUBE WAS RUPTURED

The sanitary authorities state that, as a general rule, the waste material thrown into domestic dust bins contains about 55 to 65 per cent of combustible matter. Analysis of this combustible material shows that it consists chiefly of coal, coke, breeze and cinders, paper, rags, straw and vegetable refuse.

For steam-raising purposes, this refuse may be burnt in two ways. In the first method, it is dumped from the carts into a receiver which is hoisted to the top of the furnace, and the refuse is delivered through an overhead door on to the fire. In the second method the refuse passes first of all over a drying hearth before being fired, either mechanically or by hand, into a furnace side-door. From what the author has gathered at the majority of such steam-raising plants, the second method is by far the better, though initially more expensive.

BRITISH COMBUSTION ENGINEERS ADVOCATE PURCHASE COAL ON CALORIFIC BASIS

THERE IS some agitation on the part of power plant owners in Britain against the system of purchasing coal without a guarantee of some sort as to the calorific value of the fuel bought. W. M. Miles recently urged that vigorous action is essential if power plants are not to become dumping grounds for colliery refuse. Not only is this action necessary from the standpoint of steam-raising efficiency, but, besides the general deterioration in heating value of the coal supplied, the percentage of ash has increased so much that the extra cost of handling the coal and ash is, in itself, a heavy item in operating charges. And then authority states that British coal now supplied to power plants has decreased from an average of 13,000 B.t.u. per lb. and 10 per cent ash in 1913, to 11,000 B.t.u. per lb. and 15 or 16 per cent ash in early 1921.

There are certainly a few plants where coal is purchased on a calorific basis, but it may safely be said that less than 5 per cent is bought in this manner. Owing to the existing high prices of coal and the need for the strictest economy all-round in British plants, every combustion engineer is in favor of such action.

The Smoke Nuisance in Britain

British combustion engineers, especially in London, are interested in the efforts of the Ministry of Health to reduce the smoke nuisance. In view of the inquiries that have been received from those interested in the campaign, it is of interest to learn that Lord Newton's Committee, which is inquiring into the present state of the law with regard to the pollution of the air by smoke and other noxious vapors, has nearly finished collecting evidence and is considering its final report. The committee was originally appointed in 1914; but owing to the war, operations were suspended until January of this year. This committee has examined a large number of witnesses and much valuable work has been done. Factory combustion engineers in and around the British cities are naturally interested in the final report about to be published, since it may recommend legislation involving enormous expenditure by the power plants of factories in congested neighborhoods.

Brittle Tube Causes Serious Boiler Explosion

A recent boiler explosion in England shows that, in spite of frequent examination and renewals, there are factors outside the control of the engineer which will lead to disasters involving loss of life.

Such was the case in a Thompson water-tube boiler which exploded at a mill and killed an ash-wheeler. This boiler had three steam drums 4 ft. in diameter by 17 ft. long, and three water drums 3 ft. 3 in. in diameter by 13 ft. 4 in long. Each pair of upper and lower drums were connected by 140 tubes of 3¼ in. diameter. The tubes, some of which were solid drawn, and others tap welded, were in straight lengths and expanded into the drums. Adjacent steam drums were also connected by 30 equalizing tubes, and the water drums were similarly connected, having 22 circulating tubes between the front and middle drums, and 13 between the middle and back drums.

A superheater consisting of two headers, and a number of small U-shape tubes had been installed, the elements extending into the chamber between the banks of tubes which connect the front and middle pairs of steam and water drums.

The boiler was of steel, the safety valves being loaded to 200 lb. pressure per sq. in.

This boiler was made and purchased in 1919 and was just 2 yr. old when the explosion occurred.

During 1919 and 1920, no fewer than 74 renewals to various tubes were carried out; the boiler was frequently inspected by the power engineer and the insurance inspector; and, in spite of these precautions, one of the tubes in the front bank, shown in the diagram, was ruptured longitudinally for a length of 23½ in., at 6 ft. 7 in. from its lower extremity.

On analysis, the burst tube showed very little sign of corrosion, the thickness near the fracture being 0.137 in., or 0.023 in. less than its original thickness. A test piece taken from the tube near the line of failure gave an elongation of 5 per cent in an 8-in. length, the tensile strength being 31.88 T. per sq. in. Bend tests were also carried out, and while the material withstood bending to 180 deg. without fracture over an axis at right angles to the longitudinal axis of the tube, the pieces failed in all cases when bent over an axis parallel to the longitudinal axis of the tube before 90 deg. was reached. The fractures in all cases revealed streaks of fine and coarse crystalline metal, and there is no doubt that the material from which the tube was made was quite unsuitable for that purpose on account of its brittle nature.

Prevention of Corrosion in Pipes

Corrosion May be Mitigated by Either Treating the Fluid Carried or by the Application of a Suitable Coating

CORROSION of iron and steel apparatus used for the heating and piping of hot water is a condition with which every engineer is more or less familiar and it is seemingly a foregone conclusion that wherever there is iron in the presence of water, rusting and pitting must result. As a matter of fact, experiment has shown that such is not the case; water alone will not corrode iron to any appreciable extent; and only when there is acid or air dissolved in the water is the effect noticeable.

The first step in the process of corrosion as pointed out by J. M. Speller in an address before the American Society of Mechanical Engineers, is the solution of the iron in water. Water is our universal solvent, being able to dissolve, to a greater or less degree, nearly every substance, acting in this respect as a weak acid. When water comes in contact with iron, a small amount of iron goes into solution, and, if the water is pure, the action ceases in a comparatively short time when the solution has become saturated. If, however, the water contains oxygen in solution, this unites with the iron in the form of ferrous hydrate to form insoluble ferric hydrate, which is ordinarily known as rust. At the same time, the oxygen serves to depolarize the iron and the action goes on indefinitely as long as there is oxygen present, but may be stopped at any time by simply shutting off the supply of air.

The amount of air which can be held in solution in water varies inversely with the temperature and pressure, being zero at the boiling point. An obvious method, then, of preventing corrosion would be to rid the water of air by heating it. If the water is heated to a temperature just below the boiling point and then cooled, if necessary, in the absence of air, we have a supply that is free from air and cannot, therefore, cause corrosion. This principle is practically applied in a device known as a deactivator. The apparatus as described by Perry West in a paper read at the National Exposition of Chemical Industries, consists of three sections, one above the other; the lower section is an exchanger in which the cold water entering is heated to about 140 deg., depending, of course, on its initial temperature, by the hot water leaving. The middle section is a thermostatically controlled instantaneous heater, in which the temperature is further raised to about 207 deg. by a steam jet. At this tem-

perature the water enters the top section where it spills over a series of trays, thus exposing a large surface and allowing the dissolved gases to escape to the atmosphere. The deactivated water then passes through the exchanger and leaves the apparatus at about 100 deg.

Another method of accomplishing the same result is to deliver hot water from a heater to a large tank that is completely filled with scrap metal. This metal will be corroded instead of that encountered later on in the system, thus saving the latter. The rate of the chemical activity taking place varies directly with the temperature so that it is advisable to have the water as hot as possible. At 50 deg., complete deactivation may require as much as 24 hr., whereas at 210 deg., the desired result may be effected in 2 min. By providing a tank of sufficient capacity, the water will leave the tank almost incapable of further corrosive action. Water leaving this tank will contain a considerable quantity of rust in suspension which should be filtered out before it is used.

In this apparatus the water does exactly what it would otherwise do in the piping of the system, but instead of destroying expensive and inaccessible pipe, it makes rust out of metal that can easily be renewed for a few cents a pound.

Where it is impractical to heat the water as in city supplies, dissolved air may be removed by spraying it into a vacuum. Water sprayed into a vacuum of 28 in. will have its air content reduced by about 90 per cent. The water supply to a town in Australia is piped a distance of 351 mi. through a 30-in. main, and as corrosive water would prove excessively costly in this system, a vacuum deactivator was installed. The water was sprayed into a vacuum of 28 in. maintained by the natural flow of the water, with the result that 90 per cent of the air was removed and the corrosion of the pipe reduced to less than 10 per cent of the normal rate.

Protection of the inside of piping may be effected by the application of some kind of coating, such as well refined asphalt or coal tar, concrete or neat cement. The 11-ft. pipe sections of the Catskill Acqueduct were lined with 2 in. of Portland cement grouting after having been first pickled and then given a coating of whitewash to prevent rusting. Since the pipe was installed in 1915, no ill effects due to corrosion have been noticed.

Finish and structure of the metal itself has a good deal to do with the rate of corrosive deterioration. The metal should be as homogeneous and as free from strain as possible to limit electrolytic action. For this purpose, wrought iron or steel pipes should be thoroughly worked in the process of manufacture and should be well annealed. Mill scale or magnetic oxide is effective in accelerating the action where oxygen is present.

External corrosion, as of oil or water pipes laid underground, can be effectively checked by the application of a metallic or non-metallic coating. Underground corrosion may be accelerated by the presence of certain salts or acids in the soil and by the ready access of free oxygen, either by direct circulation or by underground waters. The action is greatly increased by the contact of the metal with any materials which tend to intensify galvanic action, such as cinders. It is important that water be excluded from contact with the metal, and to this end, the trench should be well drained.

A waterproof coating applied to the pipe has been found effective in reducing deterioration. This coating may either be applied at the shop or in the field, but the former is usually preferable, as the pipe surface can more readily be cleaned of scale or rust.

One large pipe manufacturer uses the following procedure for coating pipes for this service. The pipe is first dipped in an acid pickling solution to remove all scale, and then in an alkaline washing solution. It is then heated to about 212 deg. until perfectly dry, when it is dipped into a bath of hot asphalt, coal tar, or mineral rubber compound and allowed to remain there sufficiently long for the pipe to acquire a temperature of 300 deg., the temperature of the bath. The pipe is then raised on end and the excess coating allowed to drain off. When it is cool, a fabric saturated with the coating material is wound around the pipe, after which the surface is covered with a thin layer of Portland cement. For extreme conditions, a number of layers of coating may be employed. In the field, the pipe is laid in the trench between forms and covered with several inches of concrete, after the joints have been covered with tar or asphalt. The concrete should be sufficiently fluid to completely fill the space under the pipe. If the forms are removed when the cement has set, the whole should be given a coat of tar before the trench is filled in.

Such protection has proven itself entirely successful in prolonging the life of piping laid under severe conditions and the extra cost is not to be compared with the saving in replacements that may be effected.

To Stop Static Electric Troubles

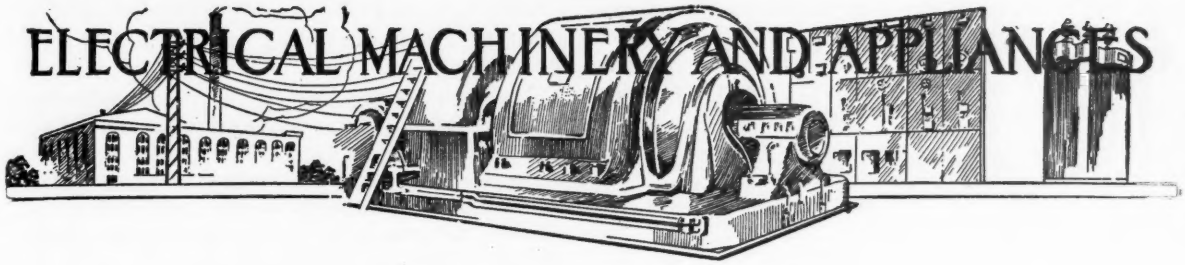
By N. G. Near

MOST users of belts have had trouble with static electricity which is often a dangerous thing, especially in flour mills, grain elevators, coal mines, or wherever dust explosions may occur.

Static electricity is always caused by friction in some form or other. The best cure, therefore, is to eliminate the friction if possible. In belts this may be and often is due to belt slippage. If the belt is not allowed to become too dry by keeping it treated with a good belt dressing so that it will not slip, the starting troubles can usually be eliminated.

Where this treatment fails to do the work, soft metallic brushes suspended over the belt in such a way that actual light contact is made without wearing or interfering in any way with the operation of the belt will take care of the difficulty if the brush is grounded. This remedy is frequently used and solves the problem effectively.

AN EXAMINATION has been made by Bureau of Mines Engineers of development work on a deposit of lignite near Reno, Nev. Preliminary experiments looking toward possible beneficiation of the material have been made. The shaft is about 45 ft. in depth and discloses a seam of lignite at least 30 ft. thick at the opening. The material improves with depth and it is hoped that it may be available as a domestic fuel after briquetting and possibly as a power fuel in the vicinity of Reno.



Protection of Electrical Equipment---II

DISCUSSING MORE OF THE TRANSIENT PHENOMENA IN ALTERNATING CURRENT CIRCUITS AND MEANS OF PROTECTING AGAINST ABNORMAL CONDITIONS. BY H. W. SMITH*

THE OSCILLATING ARC is the most frequent and most serious cause of high potential disturbances originating in the electric circuit. The voltage disturbances often cause breakdowns at points remote from the original seat of trouble. These disturbances can be eliminated by grounding the neutral.

There are certain other advantages in grounding the neutral which may or may not apply on any individual systems.

With a grounded neutral, it is possible to install relays which will disconnect any grounded section and thus confine any disturbance to a limited area. Particularly in cable systems, the majority of troubles are grounds, which unless quickly removed soon develop into short circuits. A grounding resistance can be used of such a low value that enough current is passed to operate the ordinary overload relays.

If a resistance of greater ohmic value is installed, an overload relay calibrated for low currents can be used for the purpose of disconnecting the grounded section. Special arrangements such as the Merz-Price balanced relays and split conductor cables will, in case of grounded neutral, disconnect grounded feeders.

If neutral is to be grounded, it is usual to connect transformer banks delta star and ground the neutral of the transformer, whereas, isolated systems are usually delta delta. The star connection on the high tension side gives a primary winding with voltage 58 per cent and current 173 per cent of values for delta connection. These mean more rugged coils and for high voltage transformers the cost would be less than for delta connection. Graded transformer insulation may be used in transformers where neutral is solidly grounded.

With a solidly grounded neutral, the maximum potential to ground cannot exceed 50 per cent of the line voltage. In non-grounded systems in case of ground on one phase, the two remaining lines are raised to line voltage above ground, and higher if oscillatory. If the neutral is grounded through any appreciable resistance, such for instance as a resistance which with normal phase voltage would pass double full load current, the drop across resistance is nearly phase voltage and voltage to ground or other lines will be practically line voltage. Relays, however, are designed to clear the grounded line immediately, so that under normal operating conditions the potential to ground does not exceed 58 per cent of line voltage. As far as we know, however, it is not general practice to reduce the size or number of insulators in grounded neutral system as compared to ungrounded system, but rather take advantage of increased factor of safety.

The use of a grounded neutral with a balanced protection scheme will enable a generator to be instantly disconnected in case of a ground. It is usual practice to use these relays to open the generator breaker, neutral switch, field switch and in some cases to shut off steam.

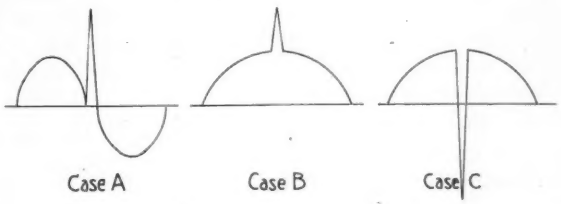


FIG 8

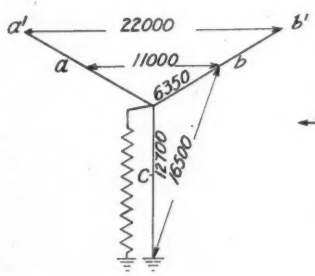


FIG. 7

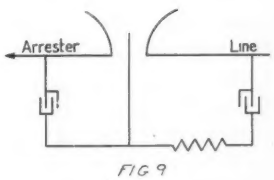


FIG 9

FIG. 7. 22,000 V. FEEDER SUPPLIED THROUGH AUTO TRANSFORMERS AND GROUNDED THROUGH RESISTANCE
FIG. 8. POSSIBLE COMBINATIONS OF IMPULSE AND LINE VOLTAGE
FIG. 9. CIRCUIT FOR USE WITH IMPULSE GAP

The grounding of the neutral enables static to be drained away, and prevents any rise in potential occurring on the whole system due to this reason.

With the grounded neutral system it is conceded that any ground on the system at once produces a short circuit through the affected phase, and the feeder in trouble must be disconnected, but the great advantage of the grounded neutral system outweighs this disadvantage.

It was formerly argued that the chief advantage of the ungrounded system was that it could be operated with one phase grounded. It has been found, however,

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that on all large systems it is not feasible to operate one wire grounded on account of voltage disturbance from arcing ground and excessive inductive interference. There is also risk to life and property operating with a line wire grounded.

How to Ground the Neutral

The neutral may be grounded either solidly or through resistance, depending on conditions that exist in the particular case under consideration. In some instances it is essential that the ground connection be solid to avoid raising parts of the system above normal potential, as for example, would result where auto transformers grounded through resistance, are used. Take the case of a 22,000-v. feeder supplied through auto transformers from an 11,000-v. system grounded through a resistance. If a ground occurred on the 22,000-v. system, the short circuit through the resistance would raise the potential of the neutral to approximately 12,700 v. above ground. The terminals a and b Fig. 7 of the 11,000-v. system would be raised to 16,500 v. above ground instead of 6350 v. While under the standard rules of the A. I. E. E. the apparatus would withstand initially a potential of 23,000 v. for one minute, it is probable that the equipment subjected to the unusual voltage strain, has been in service for some time and would be more or less dirty and also be under the strain for longer periods, so that it would be dangerous to operate under such a condition.

In the case of generators star connected, the usual place to ground the neutral is at the generator neutral. A ground on the system is a short circuit so that resistance is put in the neutral to limit the current which can flow at the time of a ground. On a system already installed where it is not desirable to change the existing relay system, suitable resistance is put in the neutral to limit the current in case of a ground to approximately twice the current rating of the heaviest feeder. This will generally give sufficient current to operate overload relays and still not give a current so large as to cause overload on the circuit breakers, distortion of machine windings, or too great an arc at the point of the ground. Also if the current be kept within reasonable limits, too great voltage drop will be prevented and synchronous apparatus is not likely to fall out of step. Usually such a system has only two relays to protect against overload, so that when the neutral is grounded it is necessary to add a third relay. An alternate scheme, however, is to use a much higher resistance in the neutral and use a relay scheme. If a ground occurs on any line, the sum of currents in the three current transformers is no longer zero, and the difference will flow through the ground protection relay which is usually an induction type overload relay with a special low current winding. This arrangement eliminates the possibility of damage from heavy currents when any phase grounds.

Where several generators are operating in parallel, it is usual to ground only one machine at a time. This can be done by connecting the ground resistance to a bus and then connecting each machine neutral to the bus through switches, only one of which is closed at one time.

If all neutrals were grounded, any difference of wave form would cause circulating currents to flow between the machines.

If tests show that there is no neutral difference in the wave forms, there is no objection to grounding all the neutrals.

In cases where a neutral cannot be obtained such as delta connected generators or star connected machines in which the neutral is not brought out, the following methods of grounding can be used:

(a) A bank of transformers connected star-delta can be used, the star side should be connected to the system to be grounded and the neutral point grounded. The other winding must be connected in delta. If the other were not connected in delta, under no condition could the bank of transformers pass more than current sufficient to magnetize the transformer. The size of transformer should be such that sufficient current flows to operate the relays.

(b) Interconnected star auto-transformer, or "so-called" zigzag transformer.

(c) Star-star auto transformer shell type with tertiary winding delta connected.

(d) Three-phase core type auto transformers.

Where generators are connected directly to step-up transformers which are paralleled on high tension side, and it is desired to disconnect generators whenever a ground occurs, in the low tension circuit, it is necessary to ground the neutral of all generators. In this case, no currents can circulate between machines.

It should be remembered that grounds on one side of a transformer bank do not give protection against surges which may occur on the other side of the bank.

With high tension transmission schemes, the neutral point of the transformers are grounded, and if it is desired to protect the generators against arcing grounds the generator neutral should be grounded. Particularly where there are outgoing feeders, the generator neutrals should be grounded.

Where there are a number of step-up transformers in parallel, it is usual to connect all neutral points to a grounding bus through disconnecting switches and ground the bus either solidly or through a resistance. Sometimes not all the transformers are grounded, as sufficient grounding current is obtained to operate the relays with less than the full number.

In the grounding of neutrals, the question arises as to whether it is advisable to install more than one ground connection. So far as the question of safety to the system and the apparatus on it are concerned, the more points that are grounded the better; however, when two or more neutrals on the same system are grounded, there is apt to be an exchange of current through the ground between the points. These circulating currents are usually of high frequency and sometimes render telephone and telegraph circuits in the neighborhood inoperative. Where there are several generating stations, it is usual to ground the neutral at each station unless interference trouble is encountered. Some systems in addition ground the neutral at all important substations. Each case, should, however, be considered separately.

Grounding Resistance

The grounding resistance is generally metallic grid type, though in some instances water rheostats are used for high tension grounding resistance. The grids are generally designed for a time rating of from 10 sec. to 2 min., allowing a maximum temperature rise of 600 deg. C.

For large cable systems up to 13,200 v., ground resistances used vary from 2 up to 8 ohms, with average time rating of 1 min., though in many cases it is 2 min.

As generators are usually protected only with differential protection, a ground on the bus would not operate any switches, and the grounding currents would flow till the operator opens the switches by hand. It is considered best practice to make the low tension grounding resistance 2 min. rating. For high tension side a 10 sec. rating would seem ample, as any ground should be removed in considerably shorter time. Voltage disturbances may be caused by switching and by lightning.

Charging a Short Transmission Line

A short line may be considered as a condenser. There will always be a certain amount of inductance in the path through which the charging current must pass to reach the line so that we have the case of the charging of a condenser through inductance with more or less resistance in the circuit. Therefore, when the line is connected, it rises to double potential (neglecting losses) and immediately starts to oscillate between this point and zero until the oscillation gradually dies out and leaves the line at normal potential.

If, on the other hand, the bus bar from which the line is charged has not the capacity to deliver almost instantly the amount of electricity necessary to charge the line, the first effect of closing the switch will be not to raise the potential of the line to its full amount, but to make both line and bus bar take an intermediate potential so that the line comes up to normal potential by step.

Protection From Line Disturbances

The protection of apparatus from line disturbances or from lightning takes two general forms: First—The choking back of the disturbance by the use of choke coils. Second—The dissipation of the disturbance to ground through an arrester of some kind.

Voltage disturbances due to lightning are usually of very high frequency. These surges tend to build up very high voltage between turns of the first inductive winding they come in contact with.

The effectiveness of a choke coil depends upon the ability to change the high frequency disturbance into a high voltage that can be dissipated to ground through the arrester.

To afford protection an arrester must function with minimum delay, must discharge with maximum freedom and then restore normal conditions with minimum disturbance.

For protection of power apparatus the electrolytic lightning arrester is superior to anything yet produced. There are two essential properties of this type of arrester:

1. The fact that it offers a very high resistance to the flow of current at normal voltage and a very low resistance to current at abnormal voltage.
2. Its electrostatic capacity by virtue of which its effective resistance to current at normal frequencies is great, but to currents at high frequency small.

The vital property of the electrolytic arrester is due to a film of aluminum hydroxide which is deposited on an aluminum plate immersed in a suitable electrolyte. At normal frequency the impedance of the arrester will permit ½ amp. to flow and to prevent overheating of the arrester by such a current, gaps are inserted between the line and the arrester. Normally they insulate the arrester from the line, but at excess voltages they are over and permit a discharge through the arrester which relieves the abnormal stress.

In order to compare the action of various gaps, arresters, etc., such terms as impulse ratio, equivalent spark gap, etc., have come into use.

Impulse ratio is defined as the ratio between sparkover voltage of the gap, on a surge of steep wave front and the sparkover voltage at 60 cycles.

A low impulse ratio indicates that an arrester will start to give protection quickly and if less than 1, means that the arrester gave greater protection the higher the frequency.

Equivalent spark gap is the length of a gap which in multiple with the arrester will just take a static discharge in preference to such a discharge passing through the arrester. It is an indication of the freedom of discharge of the arrester.

Within the past two years a new gap has been developed which is superior in protective value to any other gap. The plain horn gaps have considerable time-lag, allowing a high-fire frequency surge to rise to a much higher voltage than would a low-frequency surge before discharging and giving protection. The development of the sphere gap partly prevents this situation by eliminating the time-lag so that all frequencies are discharged at the same voltage. The new impulse gap has a negative time-lag; that is, the higher the frequency, the lower the voltage at which the gap discharges. Thus the impulse gap automatically selects the dangerous surges and gives protection more quickly than any other known form of gap.

The impulse gap not only incorporates all of the virtues of the horn gap and the high-speed sphere gap, but also possesses the property of selecting high-frequency or steep wave front surges and discharging them at a lower voltage than the normal voltage setting of the gap. It should be particularly noted that the impulse gap is the only device which will protect insulation against a steep wave front surge of reverse potential, that is, a sudden drop in voltage. The high-frequency discharge voltage may be as low as two-thirds, or even one-third, of the normal-frequency value. It is, therefore, possible to use a gap setting that will permit of the desired degree of protection against dangerous surges while not permitting too frequent discharging on minor surges at normal frequency.

The high speed of the sphere gap as compared with the horn gap is due to the elimination of the time required to build up a sphere of equal-potential surface

at the discharge of the horn gap. The sphere of the sphere gap provides at once for this sphere of equal potential surface and practically eliminates corona and reduces field distortions when the gap is set equal to, or less than the sphere diameter. By the use of the sphere gap the voltage to ground, or the breakdown voltage, at any frequency does not materially exceed the 60-cycle discharge voltage of the gap; however, the sphere gap does not give the desired protection against deep wave front, or high frequency surges, due to its inability to discharge these disturbances at lower voltage than the normal frequency setting of the gap. It is necessary to set all arrester gaps for a sufficiently high normal frequency breakdown voltage so that they will not discharge too frequently on comparatively harmless low-frequency switching surges. With the impulse gap, however, the advantage of this high normal frequency setting of the gap can be had without the corresponding disadvantage of reduced protection, since the high frequency break-down value of the gap is much lower. This is because high frequency discharges start from the auxiliary electrode and have only one-half of the gap to jump. The latter electrode, also, is shaped so that although the gap is one-half of the main gap, the breakdown is only about one-fourth as great; that is to say, high frequency surges not only are delayed in discharging, as with plain horns, by the need of building up of a static field; but instead, discharge at a voltage even lower than the normal value of the main gap, since they automatically select the auxiliary gap of much lower voltage breakdown.

The impulse gap uses a circuit, Fig. 9, that at normal frequency, is balanced as to voltage, but becomes unbalanced and starts a discharge in the case of any high-frequency surge. At normal frequency there is no difference of potential between the midpoint of the condensers and the auxiliary electrode midway between the auxiliary horn and sphere gap. A high frequency, however, passes freely through the condensers and piles up its full voltage across the resistance, that is, across one-half of the total gap. This gap, therefore, breaks down, resulting in the total voltage being impressed on the remaining gap, which breaks down in turn, dissipating the disturbance to ground. The breakdown of each half of the gap is facilitated by the fact that the auxiliary electrode is small in size (having needle gap characteristics) so that the discharge voltage of each half of the gap is about one-quarter, rather than one-half, of that of the total gap between the spheres. It should be especially noted that the danger to apparatus from steep wave front surges, particularly of reverse potential, may be out of proportion to their actual magnitude, due to the inductance of the apparatus, which not only produces a high voltage, but also a much higher voltage to ground than the normal voltage of the impulse, due to the addition of induced or reflected voltage to the normal voltage of the impulse. If the apparatus is to be protected with a gap and lightning arrester, the gap should be one that will select and discharge the high frequency disturbances at a voltage lower than the normal voltage of the gap. The impulse gap accomplishes the desired result.

The necessity of selective action in the gap is emphasized by the following possible combinations, Fig. 8, of the impulse and line voltage. (Assume that an ordinary sphere gap to ground is set to discharge at twice the line voltage.)

Case A.—The voltage of the line does not affect the action of the impulse, and the impulse must reach twice the line voltage before the gap protecting the apparatus will discharge.

Case B.—The voltage of the impulse must reach only the same voltage as that of the line, before the gap discharges.

Case C.—The voltage must have a value three times the line voltage before the gap discharges. In this case, it is to be noted that the conditions are such that the high-voltage stress is present not only to ground, but also between turns of windings of apparatus. Adequate protection against this condition demands the use of a gap which is very sensitive to steep wave front surges. If the impulse is oscillating, the second half cycle may cause a discharge, but the time for protection against the destructive effect of the first half cycle will have passed.

It is to be noted that with the impulse gap, the discharge begins at a lower voltage than with a sphere gap, and hence, operates more quickly than a sphere gap.

Experiments show that the impulse ratio of the needle point or plain horn gap is approximately 2, sphere gap 1.0 and of the impulse gap in commercial form about 0.6.

It has been found experimentally that outdoor gaps must be set at a greater distance apart than indoor gaps due to rain or wet conditions. The moisture on the surface of the gaps tends to lower the discharge voltage greatly, which in turn causes the gaps to be set at a greater distance apart in order to eliminate the too frequent discharging on minor surges of normal frequency. Under rain or wet conditions, it has been demonstrated that the unprotected impulse gap gives about twice the protection of the unprotected sphere gap and about 1.8 times the protection of the protected sphere gap.

Periodic Testing

Insulation of new electrical apparatus is designed to withstand the application of somewhat more than twice the normal voltage of the circuit upon which the apparatus is used. But insulation is subject to deterioration and the operator of such apparatus should take means to assure himself, from time to time, that this insulation still remains in proper condition. About the only way this result may be secured is to apply insulation tests to the apparatus periodically. Just what proportion of the original test is necessary or advisable to apply is an open question. The double voltage applied when the apparatus is new, is presumably a larger margin of safety than is reasonable after the apparatus has been in service for a period of years. It is the writer's opinion that 150 per cent of normal voltage is the minimum to which the insulation should be allowed to deteriorate; if the insulation will break down on the application of 150 per cent of normal voltage, the apparatus should be rewound or some other radical steps should be taken. The opinion of other engineers may place this value at some other proportion

of normal voltage. The crux of the matter is that it is necessary to maintain the insulation of electrical apparatus in good condition before the user of that apparatus can be assured that it is not on the verge of breakdown at any time, and the only way to obtain this assurance is by these periodical insulation tests.

Deterioration of electrical apparatus depends on:

(a) Overloads. (b) Abnormal voltages due to grounds, lightning, switching, etc. (c) Vibration due to improper alinement, poor foundations. (d) Dust and dirt. (e) Sweating.

In locations such as steel mills, it is advisable to follow the following recommendations:

(a) Provide house to protect motor and control apparatus from mill dust and gas fumes which attack insulation and corrode brass and copper parts. Corrosion is very destructive to these parts, particularly to commutators, and works into connections not soldered.

(b) Proper ventilation should be provided. Air washers should be provided, if clean air supply is not available. Velocity of air in duct should not exceed 2000 ft. per min. Velocity of air in washer should not exceed 600 ft. per min. Air intake provided with two openings, one arranged to take air from inside of motor room, and other to take air from outside of building. This is necessary since in winter air from outside will carry snow and ice into windings.

(c) Machine should be carefully dried out.

(d) Exposed parts of windings and particularly the creepage surfaces over the windings should be gone over at least once a year with good insulating varnish, most of the varnishes dry in from 24 to 48 hr. Machines should be blown out with moderate pressure air blast.

(e) If large high voltage motors are out of service, they should be kept warm to prevent sweating by switching 220 v. on the winding.

In closing, the writer wishes to emphasize once more the necessity for "eternal vigilance." Only by the exercise of continual care and careful supervision can the operator of electrical apparatus hope to maintain his equipment in proper running condition.

Some Recent Developments in Induction Motor Starting*

A Discussion of Some Recent Developments in Starting Polyphase Motors of the Squirrel-cage Type. By Willard C. Spencer

IN the past it has been common practice to start induction motors of the squirrel-cage type by applying to the motor terminals a certain percentage of the line voltage, usually 60 or 70 per cent, obtained from the line by means of auto-transformers, and then, as soon as the motor has come up to speed, to disconnect it from the transformers and quickly connect it directly to the line. One serious objection to this method of starting lies in the fact that not only is a heavy rush of current drawn from the line when the motor is first connected to the line through the auto-transformers, but there is also a second heavy current rush when the motor is disconnected from the auto-transformers and connected directly to the line. This second current rush may cause as great, or even greater line disturbance than in initial current rush. To a certain extent the magnitude of this second current rush depends upon the length of time taken to throw the starter from the starting to the running position. In general, the longer this time the greater the current rush. But this is not the only factor which determines the second current rush. An appreciable length of time is required for the magnetic field of an induction motor to die down after the motor has been disconnected from the line. This is especially true of a squirrel-cage induction motor of large size. It may, therefore, very well be that the magnetic field of the motor does not by any means entirely collapse during the time interval taken to throw the starter from the starting to the running position, in which case the second current rush may be largely determined by the phase relation of this remaining magnetic field and that which the line tends to set up at the instant that the motor is connected to it.

*Abstract of paper read at the annual convention of the Association of Iron and Steel Electrical Engineers.

Continuous Torque

In order greatly to reduce this second heavy current rush a new drum type of starter has recently been developed which keeps the power continuously on the motor during the whole of the starting period. The

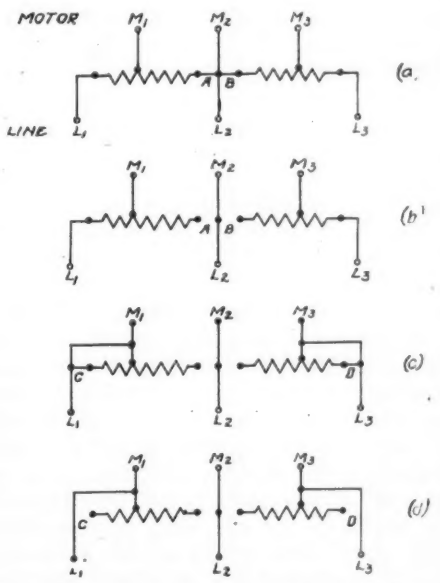


FIG. 1. SEQUENCE OF CONNECTIONS DURING STARTING PERIOD

operation of this starter as applied to a three-phase induction motor is as follows:

First—a certain percentage of the line voltage is applied to the motor terminals by means of two auto-

transformers connected in open delta in the usual way, as shown in Fig. 1 (a).

The second step is to disconnect the auto-transformers at points A and B thus leaving the motor connected to the line with a portion of the transformer windings connected as choke coils in two of the leads, as shown in Fig. 1 (b).

The third step is to short-circuit the two choke coils as shown in Fig. 1 (c).

The fourth and last step is to disconnect the transformers from the line at points C and D thus leaving the motor connected directly to the line as shown in Fig. 1 (d).

This particular sequence of switching operations not only has the advantage of keeping the power continuously on the motor but it also considerably reduces the sparking at the switch contacts as the entire circuit is never opened during the starting period.

Signal

A second means, in the form of a signal or current operated device, has recently been developed which serves still further to reduce the possibility of a second

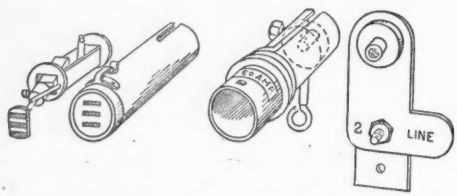


FIG. 2. DETAILS OF SIGNAL

heavy line disturbance, by advising the operator when the current drawn by the motor has fallen to a sufficiently low value to render it safe to throw the starter from the starting to the running position.

This device, shown in detail in Fig. 2, consists essentially of two small bars of soft steel placed one above the other and separated by a small air gap. One of these pieces of steel is pivoted near one end and carries at the end of a short arm a small dial marked with alternate bands or stripes of red and white. The whole signal is assembled in a fiber tube which is closed at one end by a disk having a number of narrow slots or windows through which the dial may be viewed. The signal tube is inserted in a coil which is connected in series with one of the line leads. In the normal position of the signal, with no current flowing through the coil, the white bands only of the dial are seen through the signal window. But when current of sufficient strength flows through the coil the soft steel bars become magnetized and the movable one is drawn down toward the fixed bar until the red bands on the dial show through the signal window. The number of turns of the signal coil is so selected that the signal will show red when the motor is first connected to the line through the auto-transformers and will remain red until the current has fallen to about 110 per cent of the full load current of the motor, when it changes back to white. This change of the signal from red back to white indicates to the operator that it is now safe to throw the starter from the starting to the running position.

Overload Relays

In an overload relay designed to protect an electric motor from overheating caused by overloads, some kind of slow or delayed action is desirable. The reason for this is that an electric motor is capable of carrying, momentarily, heavy overloads without injury; and from the point of view of the motor user it is desirable that such momentary overloads should not trip the relay and cause the motor to stop. What is required of the protective device is that it shall not permit the overload to remain on the motor for a sufficient length of time to cause the motor to overheat.

In order to avoid the objections of the mechanical dashpot, which is usually employed to secure the delay action and at the same time increase the delay action, a new type of protective device has recently been developed which depends for its delay action on the heating of a short strip of special sheet iron connected in series with the circuit to be protected. In this case the relay, which trips the switch, is connected in parallel with the strip of sheet iron as shown in Fig. 3. When the current first starts to flow, the iron strip, or shunt, is cold, its electrical resistance is low, and a large portion of the line current flows through it and only a small portion through the relay coil. As the current flowing through the iron shunt heats it, the electrical resistance of the shunt increases, while the impedance of the relay coil remains substantially constant, and a greater and greater portion of the line current is forced to flow through the relay, until, if the line current is great enough and continues for a sufficient length of time, the relay operates.

It is, therefore, this length of time required to heat the iron shunt by the current flowing through it that

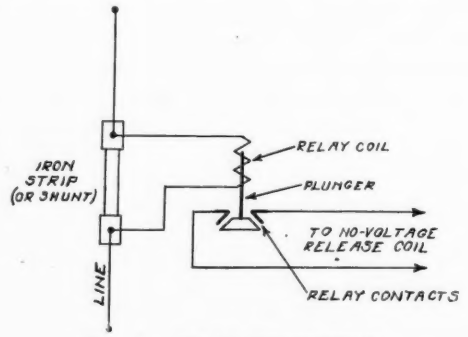


FIG. 3. RELAY CONNECTIONS

gives the desired delay action. The iron shunt is, in general, so proportioned that, at the temperature to which it is heated in about two minutes, by the current which flows through it when the motor is carrying slightly more than the maximum overload which it is capable of carrying continuously without danger of injury, it causes sufficient current to flow through the relay coil to operate the relay and stop the motor.

It should be obvious from the above that the greater the line current; that is, the greater the overload on the motor, the greater will be the current flowing through the iron shunt and the sooner it will heat and its resistance increase to a point which will cause the relay to operate. This is exactly the characteristic

desired, that is, the greater the overload the less the time the motor should be permitted to carry it.

The iron shunt operated relay has the further advantage of limiting the length of time the motor is permitted to carry a given overload in inverse ratio to the temperature of the motor at the time that the overload was applied. For instance, if the motor has been carrying normal full load for a sufficient length of time for the current corresponding to this load to heat the iron shunt to a constant temperature, then it obviously will require less time for a given overload to raise the temperature of the shunt from this temperature to a temperature sufficient to operate the relay than if the shunt and motor were cold at the time the overload was applied. This characteristic, as well as the inverse time-limit feature, is clearly shown by the curves of Fig. 4 which show the time required to operate the relay with various overloads, both starting with the iron shunt cold (room temperature) and starting with the shunt at a temperature corresponding to full load current.

As the object of the overload relay is to protect the motor from injury due to overheating, a heat actuated relay such as the relay just described which depends for its heating effect on the same current that flows through

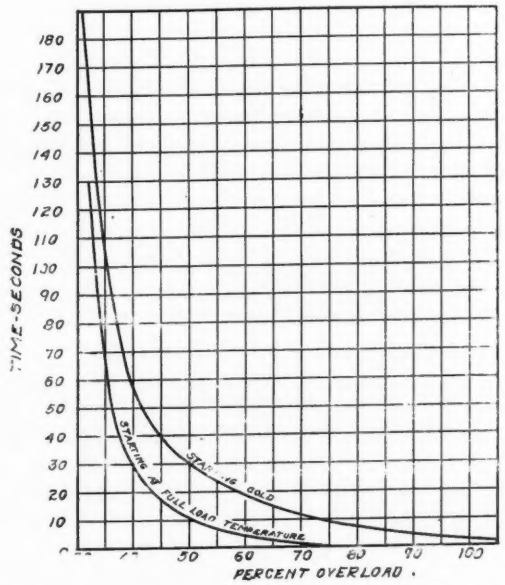


FIG. 4. CHARACTERISTIC CURVES OF SHUNT OPERATED RELAY

the motor, would seem to be the logical solution of the problem. It follows that such a device permits a motor to carry slightly more overload in cold weather than in hot weather and thus does not unnecessarily limit output of the motor.

The relays are permanently adjusted when tested and are not intended to be altered. Adjustment of overload margin is accomplished by changing the shunts. The shunts are normally proportioned to operate the relay when an overload of 30 per cent appears and lasts for about two or three minutes and to operate at other overloads as indicated in Fig. 4.

Panel

PRACTICALLY ALL the small electrical parts such as: contact fingers, drum, signal coil, shunts, relays and current studs for line and motor connections are mounted on a panel, as shown in Fig. 5, which is attached to the case by means of the studs. The case may be installed and all leads drawn in through the conduits, cut to length as indicated by the diagram inside the case, the cable tips attached and the leads bent back out of the way while there is still plenty of room inside the case before the panel, with its electrical parts, is added.

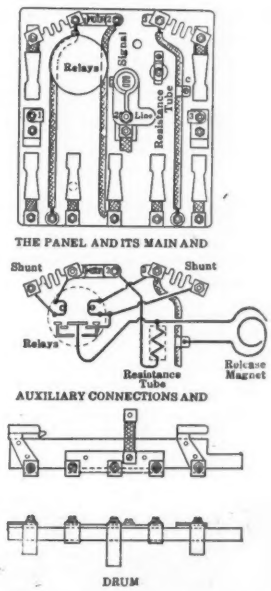


FIG. 5. DETAILS OF PANEL

In conclusion it might be stated that recent developments in induction motor starter designs seem to have been toward strict interchangeability throughout, simplification of the wiring and complete accessibility of all parts; and the design of overload relays, toward a temperature operated device, rather than a mechanical time limit mechanism for protecting a motor against injury due to overheating.

TO AID in the conservation of fuels, research into their use in heating and ventilation plants is being conducted at the Pittsburgh Experiment Station of the Bureau of Mines under a co-operative agreement with the American Society of Heating and Ventilating Engineers. Work on the following problems is now in progress under this agreement: Standardization of the measurement of dust particles suspended in air; study of combustion in domestic heating boilers; checking results obtained in the application of the testing code covering house-heating boilers; the effects on health of temperature, humidity, and motion of air in buildings and plants.

SMALL SCALE tests have been started at the Southern Experiment Station of the Bureau of Mines at Birmingham, Ala., on the combustibility and solubility of coke in carbon dioxide.

Ammonia Compressor Troubles

TROUBLES ENCOUNTERED IN THE OPERATION OF COMPRESSORS AND METHODS OF REMEDY. BY L. C. MILLER

IN a certain plant where the equipment consisted of two horizontal double-acting Vilter ice machines and one vertical, single, acting twin-cylinder York machine, a number of operating difficulties were encountered. The nature of these troubles and the method of detecting and overcoming them are described in the following paragraphs:

One of the Vilter machines gradually developed a slight knock at irregular intervals. Sometimes it would run along for days without sign of a pound or knock and then again it would knock intermittently off and on for hours at a time. The knock happened just as it passed the head and center and keying up on the crank and crosshead brasses only made matters worse, if anything.

The knock kept on getting worse and appeared at more regular intervals. We finally noticed that it was only when the machine ran quite warm that the knock appeared, and as a general rule the men liked to run the machine cold, so this accounted for the reason why it appeared only at infrequent intervals.

One day we had to do some pumping out and the machine became pretty hot. When the machine was thoroughly warmed up, the knock developed into a hard

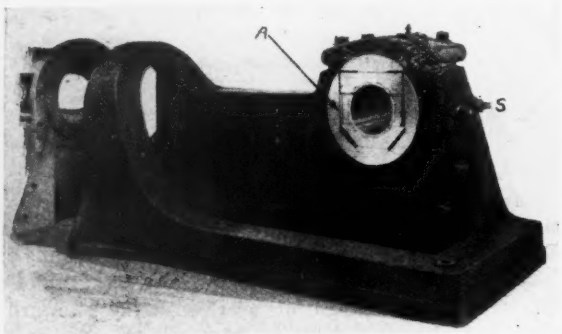


FIG. 1. SHOWING CONSTRUCTION OF PILLOW BLOCK AND METHOD OF CONSTRUCTION

thump and we finally came to the conclusion that the piston was hitting the head, which proved to be the case.

The piston rod had already been screwed into the crosshead as far as it would go, so we had to take other measures to shift the piston back from the head. It was while figuring on some method of doing this that we discovered the original cause of the trouble.

Figures 1 and 2 illustrate the construction of the connecting rod and the main pillow-block. The wedges on the connecting rod brasses had been taken up until they were nearly at the top of the slot in which they worked, showing that considerable wear had taken place on these brasses. The adjusting screws, S, of the pillow-block were also pretty far in, indicating also that considerable wear had taken place in this bearing. In fact, the machine had been run for about 6 yr. and it was about time that the bearings were rebabbited in the ordinary course of events.

The cause of the knock can now readily be seen. As all of the wear on the pillow-block was taken up by the screws S from one side only, the main shaft was gradually pushed back towards the cylinder from the center of the bearing housing. A little reflection will also bring out the fact that taking up the wear on the connecting rod brasses with the adjusting wedges had the same effect as lengthening of the rod, the centers of the bearings being pushed out towards the ends of the connecting rod. This, in addition to the shifting of the main shaft, shifted the piston back towards the head end of the cylinder and the more closely the bearings were adjusted the greater the knock became.

To remedy the trouble, we got a number of thin sheet iron shims and placed them back of the quarter-box, A, of the main bearing and the brasses, B and C, of the

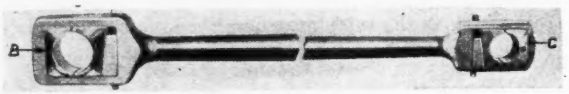


FIG. 2. CONNECTING ROD WITH WEDGES TO TAKE UP WEAR ON BRASSES

connecting rod, slacking off on the screws, S, and the wedges of the connecting brasses to accommodate these. When everything was finally tightened up, the piston came up solid against the crank end head when it was turned over and we had to back the piston rod out over a turn before we got the clearance properly equalized. This ended the trouble and also gave us considerable leeway for future adjustment.

STUFFING BOX TROUBLES

ONE DAY while we were pumping down a part of the system with one of the Vilter machines, a sharp knock started all of a sudden. We first thought that one of the valve springs on the suction or discharge valves had broken, but after we had taken them all out and taken them apart we found all of these in good order. We next tried the clearance of the piston without any better results; the knock remained.

After experimenting with everything we could think of, we finally switched over to the regular operation after the pumping down was finished and the knock disappeared as suddenly as it had appeared.

About two days later, it suddenly appeared again and this time it refused to stop no matter what we did. We finally found that by tightening up on the stuffing-box gland we could deaden it a little and this finally led to the location of the trouble.

Figure 3 illustrates the construction of the stuffing-boxes on these machines. A bushing is pressed into the neck of the stuffing-box at the point where the piston rod passes through the cylinder head, as indicated by B. This bushing was originally babbited, but evidently the rod had run hot enough to melt out the babbit, most likely at the time we were pumping out when the trouble first appeared, and when this had set again, the metal

together with shreds of packing, had practically frozen on the rod.

The bushing is a driving fit in the hole in the cylinder head and considerable force is generally required to get it out. In this case, the rods had been running for about 2 yr. since they had been turned down and there were shoulders worn at each end of the rod. The rods had been turned down twice before and there was considerable space between the rod and the bushing at the point of smallest diameter of the rod. In pumping down the packing had expanded and shreds of it had been squeezed in between the bushing and the rod, further increasing the friction and consequent heating of the rod, until it had evidently become hot enough to melt the babbit in the bushing. It must be remembered that in pumping down a machine heats up to a high temperature, and this added to the temperature caused by the friction of the tight stuffing-box and the packing squeezed in between the bushing and the rod raised the temperature to a very high degree.

The machine was provided with a liquid injection connection to both the cylinder and the stuffing-box. When the man in charge of the machine finally woke up to the fact that the stuffing-box was getting hot, he at once turned the ammonia on it, with the result that the packing cooled down with a rush, contracting it and at the same time chilling the molten babbit in the bushing, which also closed in on the shreds of packing that had worked into it between the bushing and the rod.

The machine had been shut down several times during the pumping out operation and it probably had been shut down just about at the moment that the

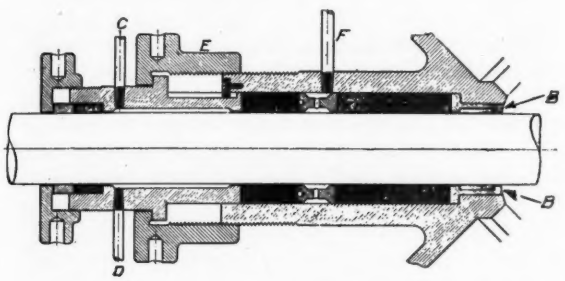


FIG. 3. LONGITUDINAL SECTION OF STUFFING BOX

babbit had began to set with the result that it had practically frozen solid to the rod. When the machine had been started again the friction on the rod had been sufficient to pull the bushing out of the hole in the cylinder head, which most likely happened when the shoulder on the rod entered the bushing. The packing had sufficient spring to permit a slight motion of the bushing, particularly when it contracted after the ammonia was injected into it, and when the motion of the rod was reversed the bushing was rammed back into the hole in the cylinder head with the force of a hammer blow. Tightening up on the packing, as we finally discovered, had, of course, a tendency to limit the travel of the bushing and reduce the knock.

To get the bushing out, we removed the packing from the stuffing-box, disconnected the rod from the crosshead and then pulled the rod back until the shoulder on the crosshead end of the rod jammed in the bushing. By pushing the piston and rod back into the cylinder, the bushing was pushed out by being jammed on the rod. After it was pushed out far enough to come outside of the stuffing-box, it was a simple matter to heat it up with a couple of blow-torches until the babbit became soft enough so that the bushing could be driven out over the end of the rod.

The bushing was then rebabbited to a diameter that was a snug fit over the ends of the rod where it had not been worn down, in order to enable us easily to replace it. The part of the bushing that entered the hole in the cylinder head was nicked in numerous places with a small, sharp cold chisel, in order to make it drive in tighter. We never had any further trouble with it.

Reference to Fig. 3 will show that there are practically two stuffing-boxes. There is the main stuffing-

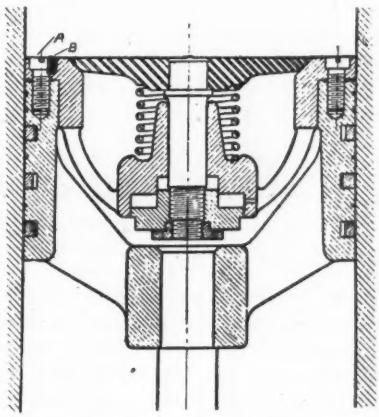


FIG. 4. SECTION ILLUSTRATING THE CONSTRUCTION OF PISTON AND SUCTION VALVE

box with two sections of packing with a lantern between. The gland for the main stuffing-box also forms an oil reservoir in front of the main stuffing-box and also another smaller stuffing-box in front of the oil reservoir to keep the oil from leaking out. This stuffing-box should only be adjusted to keep the oil from leaking out; the larger gland only should be adjusted to keep the ammonia from leaking through.

A small force feed oil pump kept the oil continually circulating through the oil reservoir and lubricated the rod. The suction of the pump was connected to pipe D and the discharge to pipe C. Generally but little pressure is necessary to keep this oil in circulation, consequently the stuffing-box on the pump plunger was not set up very tight.

One day the stuffing-box on this pump started to leak very badly, first oil and finally ammonia gas. Tightening up on the main stuffing-box nut, E, helped matters for a while; but it was not long before the rod began to smoke and it had to be backed off again, with the result that the oil and ammonia gas began to blow out of the oil pump stuffing-box.

We finally repacked the main stuffing-box, which overcame the difficulty for a few days. Then the same thing happened again. One of the men finally suggested that pipe F, which connects to the suction header of the machine, might be plugged up.

The pipe was disconnected and we found that it was plugged up tight with shreds of packing and dirt. This pipe relieves the space around the lantern in the center of stuffing-box from any pressure that may accumulate from ammonia that leaks through the first section of packing, thus preventing anything above suction pressure from being exerted against the last section of packing in the stuffing-box. When the pipe plugged up there was full pressure on the last section and unless the packing was run excessively tight it would blow through and accumulate in the oil reservoir. After this, whenever we had any similar experience with the oil circulating pump we at once disconnected the relief pipe F, and we invariably found the trouble here.

Loose Bolt Causes Knock in Cylinder

One day a knock started in one of the cylinders of the York machine. We first thought it was in the connecting rod brasses or the crosshead shoes; but after experimenting with everything that we could think of, we finally had to admit that it must be in the cylinder and there was nothing to do but remove the cylinder head and examine the interior.

When we got it open, we first inspected the false head and the discharge valve closely without finding anything wrong. When we removed the false head and discharge valve, we found, however, that one of the screws that holds the suction valve in place had become loose and backed out until it had been striking the head.

Figure 4 illustrates the construction of the piston and the suction valve, which is placed directly in the piston. The screw that caused the trouble is indicated by A. After screwing the screw down again as tight as possible, a small hole was drilled in one side of the screw and into the valve cage as indicated by B. This was filled with babbit, and after it had set the top of the hole was burred over with the peen of a ball peen hammer, which closed in the top of the hole enough so that the babbit could not work out. This locked the screw securely in place and prevented it from backing out. Whenever it was necessary to take it out, it was a simple matter to heat it sufficiently to melt it out, when the screw could be backed out easily.

Ladders and Stairways for the Power Plant

Precautions in Construction and Use to Avoid Accidents. By the Engineering Department of the National Safety Council

In meeting the needs placed upon the ladder, the character of material used in its construction varies from heavy angle steel or iron to a skeleton of wood—the degrees of permanency and the character of the load guiding in choice of materials and their fashioning.

Experience has dictated certain practices to be observed in building, placing and using ladders. The ladder should be of sufficient strength to resist safely double the strain of the heaviest load that will be placed upon it in use. This has been assumed to be about 450 lb.—the weight of a man and the burden he might reasonably be expected to carry up or down a ladder, and a like weight added as a margin of safety. The ladder must be wide enough for the user to move freely and safely about his work.

A stationary ladder is one that is so anchored or fastened, permanently or temporarily, to a structure or piece of mechanism as to become a fixed part thereof. A portable ladder is one that is to be used transiently at various locations, and may have various forms, such as:

A step ladder so constructed as to be self-supporting; a sectional ladder of two or more sections so constructed that the sections will telescope one into another, or so arranged as to be united into a single ladder; a trolley ladder having a movement confined in permanent guides or ways at top or bottom, or both; a trestle ladder whose parts, each equivalent to a straight ladder, are hinged at the top to form A frames.

Clearances

In placing a stationary ladder, a continuous clearance space should be provided, back of the ladder rungs, such as to allow a man's foot to obtain a fair purchase on the rung, as a slight obstruction to the foot or hand in gaining a hold on a rung may cause a misstep, with serious results. For this reason, general practice favors a minimum clearance of 8 in., and some authorities favor allowing a minimum of even 12 in.

Continuous clearance space should be provided in front of the ladder, so as to allow a person to assume a free and natural climbing posture. Fixed objects projecting at random too close to the front of a ladder may strike and injure the person climbing, or they may catch the clothing of the climber and jerk him loose from his hold. To eliminate such a hazard, some requirements provide for a minimum clearance space of 24 in., but 30 to 36 in. seems to be more generally favored because a workman often carries tools projecting from his pockets or tool belt that would not pass a 24-in. clearance. It is evident from the foregoing discussion that it is important to have a proper continuous clearance space of 15 in. on each side of the center line of the ladder. If ladders are used as a common passage-way, provide one or more for ascending and another group for descending.

Material for Ladder

Permanent stationary ladders should be constructed of steel or iron and should be designed effectively to resist the impact blows of falling materials and loads swinging from cranes and hoists. Ladders having side rails and fastened top and bottom, with intermediary supports, are preferable to the built-in type consisting of "U"-shaped sections imbedded in a wall or fastened to a stack. Side rails of angle steel or iron should not be less than ¾ sq. in. in cross-section, a size of 2 by ½ in. being preferred.

Ladders designed to reach safety valves, cut-outs, etc., where speed of operation may mean a saving of life, should always be of permanent type, securely fastened and constructed entirely of steel or iron.

Safe practices, applying to stationary or fixed ladders, include the following: When sections join, splice

plates shall be of same size and material as side rails and carefully riveted or bolted. Wooden ladders may be spliced with steel braces of equivalent strength. Ladders over 20 ft. in length should be built in zig-zag sections and provided with safety platforms, no open space of over 18 in. being allowed back of the landing. Brackets should be of suitable strength to support firmly the ladder and weight of workmen and burden, and should be of sufficient rigidity to resist any anticipated impact from falling material or traveling crane. They should be fastened by through or expansion bolts firmly imbedded in wall, and should be spaced not over 12 ft. apart.

Temporary and portable ladders are usually constructed of wood, thoroughly seasoned long-leaf yellow pine, Oregon fir, or northern white spruce giving good results for side rails and white ash, oak (second growth) or hickory for rungs. All material should be free from knots or shakes, although half-inch imperfections are sometimes allowable in side rails of the larger sizes of ladders if in center of stringer.

The rungs should be designed as a simple beam supported at both ends to resist safely, without permanent or readily apparent deflection, the stresses incurred by a load equal to the weight of an average man imposed at the center of the rung, plus any weight carried or supported by a man on the ladder. The minimum section of a rung should be a diameter that provides the

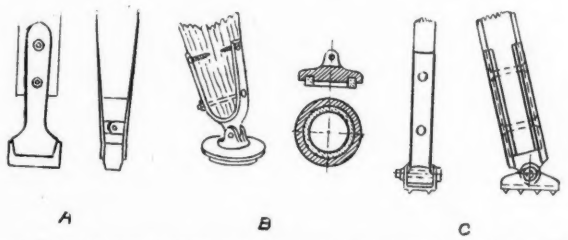


FIG. 1. NON-SLIP BASES FOR PORTABLE LADDERS. A, ABRASIVE BLOCK; B, RUBBER RING; C, SPIKED CASTING

most secure hand hold, having all the rungs in a ladder of uniform section is good as it eliminates the annoyance of varying the grip with each rise. Rungs of a ladder should be free from splinters, if wood, and burrs, if steel, as experience has shown that it is such small annoyances to the climber that cause many a misstep and fall; *spacing of rungs should be uniform.* General practice favors a string spacing varying 15 to 18 in., for metal construction a round steel or iron rung varying from 5/8 to 1 in. dia., and for wooden construction a rung of not less than 1 1/8 in. in diameter, tapered to fit a somewhat smaller socket. Excellent wooden rungs are made from blocks sawn to proper length. If of white oak blocks may be split and hand shaved to size and the ends machine turned to fit sockets in stringers. Hickory or white ash will not split evenly and machine turning will be necessary, consequently, careful selection should be made of material and careful inspection and testing made to avoid weak rungs.

Safety Bases and Tops

For wooden floors, metal points or lead-coated bases are recommended; for concrete floors, pivoted lead shoes or carborundum; for wet floors, recessed rubber bases have given the best satisfaction. For use on iron floors, carborundum has been found to serve very well, but Pennsylvania specifies the placing of an attendant at the foot of each ladder when working on iron floors. We cannot depend on any one type of base under all conditions and be safe.

Safety tops are provided for fixed ladders by omitting rungs above the highest work level running the sides shoulder-high above that level. A "goose-neck" permits a higher degree of safety. Oilers' lad-

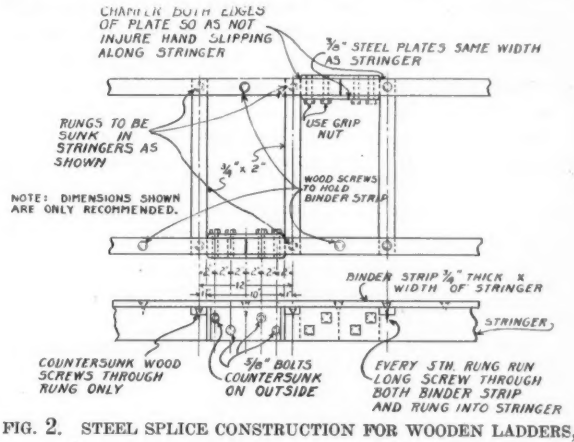

CHAMFER BOTH EDGES OF PLATE SO AS NOT INJURE HAND SLIPPING ALONG STRINGER
3/8" STEEL PLATES SAME WIDTH AS STRINGER
RUNGS TO BE SUNK IN STRINGERS AS SHOWN
USE GRIP NUT
3/8" x 2"
WOOD SCREWS TO HOLD BINDER STRIP
NOTE: DIMENSIONS SHOWN ARE ONLY RECOMMENDED.
BINDER STRIP 3/4" THICK x WIDTH OF STRINGER
STRINGER
COUNTERSUNK WOOD SCREWS THROUGH RUNG ONLY
5/8" BOLTS COUNTERSUNK ON OUTSIDE
EVERY 5TH RUNG RUN LONG SCREW THROUGH BOTH BINDER STRIP AND RUNG INTO STRINGER

FIG. 2. STEEL SPLICE CONSTRUCTION FOR WOODEN LADDERS, AND BINDER STRIP FOR SLAT RUNGS

ders, with hooked tops to fit over shafts, are becoming more and more the rule.

Convenience limits the length of portable ladders to approximately 30 ft. Ten-foot ladders, constructed of northern spruce side rails (or wood of similar strength) will be found satisfactory if of 1 3/8 by 2 3/8 in. material; 18-ft., 1 3/8 by 2 3/4 in.; 25-ft., 1 5/8 by 3 in.; 30-ft., 1 7/8 by 3 1/2 in. Rungs of 24-in. length seasoned ash should be 1 1/8 in. diam. with tenon of 7/8 in.; over 24 in. long, 1 1/4 in. diam. with tenon of 7/8 in. Width at the bottom of most types of portable ladders should be appreciably greater than at top. Figures 2 and 3 show good practice for fastening rungs to stringers.

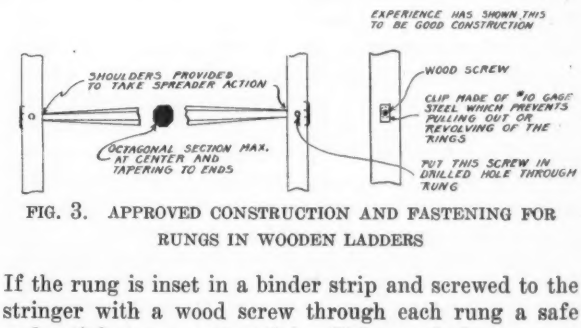

EXPERIENCE HAS SHOWN THIS TO BE GOOD CONSTRUCTION
SHOULDERS PROVIDED TO TAKE SPREADER ACTION
OCTAGONAL SECTION MAX. AT CENTER AND TAPERING TO ENDS
WOOD SCREW
CLIP MADE OF #10 GAGE STEEL WHICH PREVENTS PULLING OUT OR REVOLVING OF THE RINGS
PUT THIS SCREW IN DRILLED HOLE THROUGH RUNG

FIG. 3. APPROVED CONSTRUCTION AND FASTENING FOR RUNGS IN WOODEN LADDERS

If the rung is inset in a binder strip and screwed to the stringer with a wood screw through each rung a safe and satisfactory construction will be reached.

Step ladders should never exceed 20 ft. in length and have side rails from 7/8 by 3 in. to 1 by 4 1/4 in., the latter being used as the limit of length is approached. Steps vary from 3/4 to 1 in. thick for the heavier types and a slight increase in width is also recommended in very long ladders over the 4 1/4 in. of the shorter ladder. For every foot of length the bottom of a step ladder should be 1 1/2 in. wider than the top. Steps must afford a safe foothold, should be trussed, braced or reinforced and must be securely screwed or bolted to side rails.

Safe Practice

Use care in placing ladders. Do not place ladders too straight or at too great an angle or they may fall, break or slip. Never place ladders in front of doors opening toward the ladder. Ladders should never be placed against window sashes. Screw a board across the top of ladders to give bearing at each side of window.

Step ladders should be fully opened out in all cases before anyone steps on them. Always face ladder when ascending or descending. Do not go up or down a ladder without free use of both hands. If material has to be handled use a rope. Short ladders should not be spliced together, as they are not built strong enough to be used as long ladders.

Ladders should be kept clean and free from dirt or splashings of paint or material. Imperfections or defects are not readily observed unless ladders are kept in good condition. Iron and steel ladders should be coated with a preservative paint or composition. Wooden ladders, if used out of doors, should also be carefully treated with a suitable preservative, such as varnish or oil. Do not paint wooden ladders.

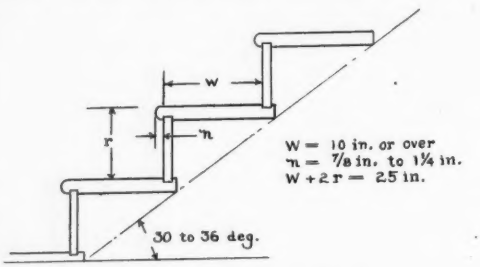


FIG. 4. SAFE DESIGN OF STAIR STEPS

Safety belts and hooks should be provided when the character of the work demands the attention of the workman or constitutes an element of danger.

Stairways

Ramps, used as a means of ascending or descending from one level to another if the grade is less than 20 deg. from the horizontal, should be rigid, with unobstructed passageway, and secure footing. If built of planks, the joints should be carefully made. Cleats should be spaced about fourteen inches apart, and should extend from guard rail to guard rail, at right angles to the line of travel, except where a runway is necessary for wheelbarrows or trucks. Splinters, nails, patches, irregularities, breaks or cracks in walking surfaces are dangerous and should not be tolerated.

Ramps with granolithic or cement walking surfaces should have walking surfaces made anti-slip by rough floating, or by incorporating 1½ lb. per sq. ft. of abrasive grit, such as alundum in the mix for finish coat, and then sprinkling another 1½ lb. per sq. ft. over the surface before giving the rough float. Others prefer the use of 4-in. wide strips of antislip tread set 10 in. on centers in the cement at right angles to the line of travel and projecting less than ⅛ in. above the surface.

If the grade is greater than 20 and less than 50 deg. from the horizontal, stairs should be used. Fixed ladders are necessary for grades over 50 deg.

For long stairways, landings between floors are desirable, dividing into approximately 12-ft. sections. Avoid doors opening on stairs, and provide landings sufficiently large to afford safe standing room outside of the space required by swing of door. Glass panels in doors opening on landings are necessary for safety, especially when swinging doors are used.

Treads

Stair treads and landings should be of sufficient strength to bear the maximum number of people that can stand upon them. Building codes generally require that the stair shall safely carry a load of 100 lb. per sq. ft. at the usual safe working stresses.

Width of treads and height of rise should be uniform for each flight of stairs, the tread giving ample width on which to place the full length of the foot when descending without danger of striking the heel against the riser above, but not so wide as to compel an increased stride. It is good practice to make the tread width (exclusive of nosing overhang), plus twice the riser height, equal to 25 in. In using this rule the thickness of the tread should be added to the height of the riser. The tread width should be further increased with a nosing overhang of ⅞ to 1¼ in., with under edge rounded or beveled.

Iron or steel treads are unsafe as slipping is possible at all times. Under ordinary conditions marble, slate, wood, and other materials are safe, but mud, oil, or wear may render them unsafe. The safe type retains an effective and anti-slip quality for long periods even under exceptional severe traffic. To this class belong cork, asphalt mastics, iron-abrasive and lead-abrasive types of anti-slip treads. Concrete treads are sometimes used with anti-slip tread inserts to protect nosing from chipping, to prevent people from slipping, and to take all the wear on an easily-replaceable insert. Sometimes they are roughened by floating abrasive crystals into the setting concrete.

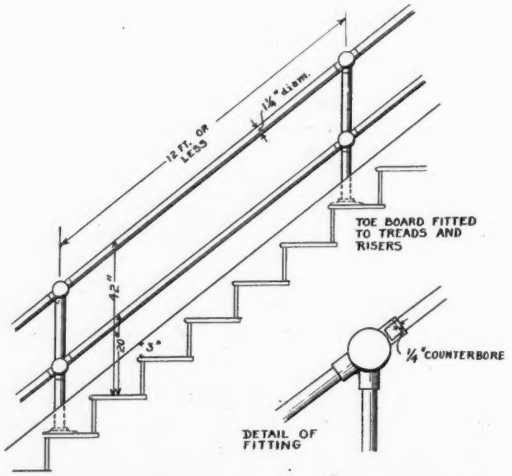


FIG. 5. RAILING OF IRON PIPE AND TOE BOARD FOR OPEN STAIRWAYS

Height of the rise in conjunction with the width of tread determines the angle of the stairs which should be between 30 and 36 deg. from the horizontal.

When the stringers of stairs do not accomplish the purpose, toe boards should be added to fit snugly to the sides of treads and risers and extend not less than

3 in. above the nosings. When stairways or runways are used for transporting materials a wire mesh guard should be filled in from toe-board to hand rail.

Hand Rails

Stairways 3½ ft. or more in width should have a hand rail on each side. Open stairways, regardless of width, should have hand rails on both sides, and stairways over 7 ft. in width should have hand rails on both sides and in the center. Measured from the center of the tread the hand rail should be about 42 in. high, because the average adult accidentally falling against the railing in ascending a stairway will strike with his weight under rather than above the rail. If the rail is properly braced, it will take up the force of the impact, and the intermediate rail will prevent the workman falling outside of the stair or runway. A young person would be saved from falling by the intermediate rail which should be provided about midway between the toeboard and the upper or hand rail.

Steel or iron angle or pipe is the best material if the railings will be subjected to strain, though wooden rails, if straight grained and free from knots, imperfections, and splinters, are sometimes used when the traffic is light.

Rails made of angle iron or steel should have chamfered edges, an even, smooth surface, and the ends rounded or flush with upright. Supporting posts should be finished in a similar manner. One and one-fourth to 1½ in. pipe, with malleable fittings counterbored sufficiently to extend at least ¼ in. beyond threads on pipe, or 2 by 2¼-in. angle steel for top rails and ¼ by 2-in. flat for intermediate rail; or 2 by 4-in. wooden top rail and 1 by 6-in. intermediate rail, will provide safe conditions. When metal hand rails are used, supporting posts or braces should be spaced not more than 12 ft. apart. The railing will be stronger and safer if riveted instead of bolted together. In wooden construction, it will be found advisable to space posts not more than 8 ft. from center to center to insure rigidity. Supporting posts and braces should be of the same or larger dimensions than the railings. Hand rails of enclosed stairways should extend about 3 in. from the wall to provide space for the hand to grip the railing and avoid scraping fingers on the wall.

Circular stairways should be avoided in new construction. Existing circular stairways with narrow treads should be closed to all except employes whose work makes it necessary to use them. When circular stairways are necessary, variation in the width of tread should be avoided as far as possible, and effective and durable anti-slip tread should be used. Warning signs should be displayed at both top and bottom of such stairways.

Arrangement

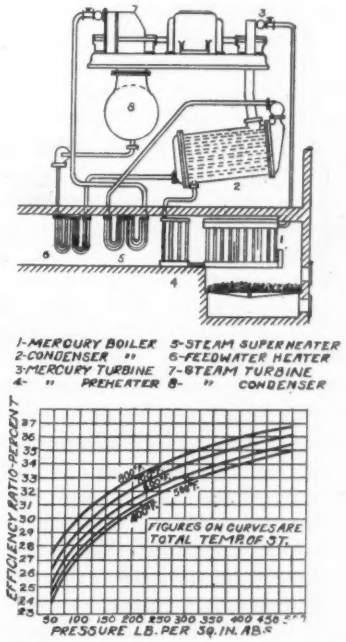
Stairways located in dark places should have ample artificial light provided, so shaded as to throw the light on the stair and not in the eyes of the users. Especially good light should be provided at the commencement of each flight, at landings and platforms so that the first tread and riser are clearly visible, as they are more important than the intermediate steps. Sufficient head room should be obtained, the vertical clearance being not less than 7 ft., measured from top of tread on a line with face of riser.

When a stairway ends in direct proximity to a crane runway, dangerous machinery, running belts, shafting, or traffic hazard, strong detour guard rails should be built and well braced to deflect traffic from the hazard. The floor at the head or foot of a stairway should always be level, or nearly so, especially in exterior stairways, and the entrance should be not less than 4 ft. from the nearest top or bottom riser.

No obstruction of any kind should be allowed in passageways leading to fire escapes, or on balconies, platforms, stairs, or landings of escapes. Each outside runway or stairway should have a cover or roof to keep off snow and ice, or if a cover is not provided, snow and ice should be immediately removed.

High Steam Pressure

Discussion of the economy from use of high pressures and temperatures in steam engines before the Institute of Mechanical Engineers is reported in Engineering of London, Eng. The efficiency obtained (ratio of work to heat energy in the fuel) is shown in the diagram.



Relation of efficiency of steam plant to pressure and temperature. Feed-water temperature 80 deg.; vacuum 28½ in.

With pressure of 350 lb. and 300 deg. superheat, exhaust at 29 in. vacuum, an efficiency of 26.38 per cent was obtained, but by raising feed-water temperature to 300 deg., the efficiency was increased to 28.44 per cent, steam for heating the feed being bled from intermediate stages of the turbine.

It was stated that in a 1500-kw. plant run at 350 lb. and 750 deg. coal economy showed 15 to 20 per cent, but the question of cost of plant was raised, since the diagram shows that at 200 lb. and 700 deg. the theoretical efficiency is 32 per cent, whereas at 350 lb. and 700 deg. it is 34½ per cent, the gain being only 2½ per cent and the cost being increased for boilers, piping and fittings to carry 350 lb. as against 200 lb.

Trouble Hunting---X

Experiences on Mexico's Cannon Ball Limited. By John Pierce

WELL, we backed up and started—we went to the depot and got ready to go aboard the train when we were informed that said train would not leave that day. Asking the cause, we found that the train had brought a general to town to visit a friend, and had decided to stay over night and attend a banquet given in his honor, and since he had come in on the train he considered it his, and ordered it held over. Such are the ways of life in poor old Mexico. The general says go, and you go; he says not, and you—not. From the highest officer in the republic to the lowest you find the same assumption of ownership of the earth, the sea, and a part of the air. In fact, all the air, for an American airship cannot fly over Mexico, while every day at Laredo, Texas, since the Mexican government got their six new planes across the river at Nuevo Laredo, one can see them go up into the air and then sail over and do their flying over God's country. As I said, in one of my previous articles, the American railroad men can't cross the boundary and do any work in the Mexican yards, but there is never a day but that the Mexican crews come over into Laredo and do more or less work on the American side. Here in Mexico the country thinks highly of its laboring man and has laws governing employment. If you employ one man he must be a Mexican. If you employ more than one man, you must employ 80 per cent Mexicans. And I think this would be a wonderful law to put into effect in the States. I've said more on this subject than perhaps I should, which is aside from hunting troubles, partly because it is the American's business to look into these things, and partly because I have to burst out every once in so often over the way we lie down and let ourselves be run over; so I'm going back to my story.

On finding that our train was not intending to go, I went back and told the superintendent, and he ordered one of our own crews to take a company engine and caboose and take me to the main line, about 50 mi. away. We waited there 6 hr. for our train, which was only 5 hr. late, fortunately, or rather very nice of it, since it was usually 7 to 10 hr. late. I bought my tickets and went to check my baggage. They weighed it up and found I had 85 lb. excess, and levied the excess price. I inquired about the express rates and found I could *express* my trunks and save the worry about them and save in the transaction 8 pesos over the excess baggage rates. I expressed them. The train finally came and we got aboard and prepared to take life easy until we returned to Mexico, for I had decided to go to San Antonio, Texas, and stock up on clothing. Nothing out of the ordinary came up on the trip out, everything being the same old game of get all they could from the gringo.

After a few days in the "Mexican" city of San Antonio we started back, I with four new pairs of shoes aboard and the wife with three. You can imagine how Uncle John felt when he found that Mexico charged an awful duty on shoes. I don't know whether we were charged according to law, or not, but those seven pairs of shoes cost me $35 gold to the Mexican custom agents.

You may be able to imagine how I felt, but I venture to say that none of you can even begin to imagine what I said—and I said it loud and strong—what is more, I said it directly to the Mexican customs men, and they—what do you suppose they did? Fired me out of Mexico, put a fine on me, or what? Well, I was surprised, for not a single one of them felt insulted at being called what I called them, and one-tenth of what I said would have had me in jail in the States. I guess they were accustomed to it, though, and it didn't hurt them.

Crossing a part of the desert country, we began to go into the foothills of the western range of mountains. Here we ran into a young revolution. Our engine was derailed and the first two cars, in addition to the engine and tender, were turned over. One of these was the escorts' car and three of the escort were killed in the turnover. The rebels were in the brush about 400 yd. distant, and armed with the Mexican army rifles, Mausers and Winchesters. We had quite a battle. There was no way of telling how many rebels we had bumped into, and we had 30 men in our escort. The battle lasted about 2½ hr. Three men were killed—the three who died when their car went over. Back in the car where Uncle John was we had a little excitement. Uncle John wanted to take his six gun in hand and go—no, he didn't want to go toward the rebels. Uncle John is too foxy for that—he wanted to go exactly the other way and come around the world, sneaking up on them from the rear.

But his wife wouldn't hear to it at all; she said, "Lie down, you old fool."

In the face of such superior orders, there was nothing to do but obey, so I lay down; I got right down in the middle of the aisle and I lay mighty low, I'll tell the world. Gee, I couldn't help but think every little while how awful thin the sides of that car were, and what an awful wallop those Mauser bullets had to them. One fellow was mighty restless. Not I, I lay there as quiet and calm, not even breathing, till it was all over. But this other fellow couldn't be quiet. When the war started, he was up in one end of the car, and he, too, lay down. Directly after the "old fool" had obeyed orders and lain down also, an inquisitive bullet came nosing along and hit the car near where my restless friend was located. He decided the other end of the car was thicker, or something, for he didn't stop to explain as he went over me, just why he was moving. Here he came down that aisle—he didn't get up and come a-running—imagine, if you can, a monkey with his Italian master, out to get pennies from the crowd; now shut your eyes and see the graceful (?) creature as he ambles down the sidewalk on all fours, his tail pointing to the blue dome of heaven, and in his eyes a gleam of—a gleam of—a gleam of—oh hell, I ain't no poet. But you know what I mean—and here came his counterpart, on all fours, gamboling along as sedately

as a cow. And, believe me, he moved fast to be coming in that manner. When he got to me, he put his hands on my back, using my head for a stepping stone and kept right on traveling. Hardly had he reached the other end of the car when another ball smashed into that end and back he came—and the only difference in the manner of his passing was that his feet left tracks on me that pointed in the direction opposite to his first ones. Well, every time a bullet hit that car this son of a gun made a trip down to the other end.

I finally got used to it, and didn't mind it so much. I looked up at him once as he was coming head on, and he had been so busy traveling that his tongue was hanging out, and his eyes were rolling like a small cork in a choppy sea.

Finally, like everything else, the battle stopped, and the rebels went away. I saw afterwards that they claimed to have won a great victory over the federal troops. But since the papers stated that the federals had won a great victory over the rebels, it was exactly balanced and nobody the worse for wear except Uncle John. And Uncle John's back was all covered with footprints. The thing that hurt worst of all, however, was the way the wife raised Cain about my clothes being so dirty, when she herself gave the orders to "lay down." I went out and counted the bullet holes in our car; it had been hit 28 times. That meant that I'd been walked, or run, over that many times also, for old friend made a trip with every bullet.

We had to wait there the rest of that day and all night, and the next day at noon had a new engine and were under way again. We passed through some beautiful cactus and finally reached a fair sized city where we had to change cars. The train which we were expecting to take was lost, and nobody knew where it was nor when it would get there. A block away was a hotel run by an American, so we decided to go there and got to bed, leaving the porter to call us when the train came in. We registered and sat down in the lobby to rest awhile before going to bed. While still sitting there, lo and behold, in came the train. We hastily started for the depot when we were hailed by the proprietor and told we had not settled our bills. Now we had not even seen the rooms, had had nothing to eat, nor a drop of water to drink—had merely used a drop of his ink to register with, and had sat in his chairs less than an hour. So, naturally, we were a little bit surprised. I asked him what the bill was going to be, and he said $6 each—think of it, gentlemen—$12 for the wife and I for what I've said we had. Well, in Mexico one can be jailed, and even shot, for debt, and I knew it was either pay the $12 to this fellow, or pay the judge at least $25 to bribe him to let me go, so I paid the bill. In case any of you, gentle readers, ever go to Mexico, let me whisper a word of warning to you. In case you go to Agua Calientes, don't go to Moore's hotel next the depot—he is the guy, and that is the place. Paying what I did for breathing the air in his hotel lobby, nobody knows what he will charge you if you stay overnight.

We got into the Pullman and found our seat. It was occupied by a Mex. who belonged in the second-class car, and I rolled him out into the aisle and we sat down. I noticed an absence of porters, etc., which pertained to the Pullman, and found that the army had used this car a few days before, and as it was in need of many things, they had carried away everything but the seats, and only left them because they were fastened down. So that there was only one thing to do, and that was to sit there all night.

In the morning, we changed cars again and started directly into the mountains. At noon, we arrived at our last changing place and sat down to wait for the train on the branch line. We were now exactly on the top of the Mexican "divide" and at one of the highest points of Mexico. The scenery was as beautiful as I had ever seen; but I was about to despair, for I thought the other train would never come, and I was hungry, since there was not a thing to eat at the junction.

After awhile—about four o'clock in the evening—a man asked me if I was going to a certain place, and told me the train was ready to go. All I could see was a little old engine that had been there all day and a box car. I was told that was the train. I went around on the other side of the boxcar and found the door open. I had to get some ties and rocks to build a way for the wife to get in, as there were no steps to the car. Once in, I hardly had room to stand; all the scum of the earth and their belongings were there; yet they had sold me a "Pullman" ticket. In 2 hr., though, of this horrible mess, we reached a cliff, where we stopped, and looked hundreds of feet down into a beautiful old Spanish city which was to be my home for several months.

Using Standard Pipes as Columns or Struts

How to Be Sure That They Are Strong Enough. By W. F. Schaphorst*

STANDARD pipes often come in handy for use as columns or struts or for use as "push members" in transmitting forces. This is because a pipe is strong both in tension and compression. Due to its circular form, it is ideal for resisting compressive forces.

When it comes to "figuring columns," however, it often takes considerable time digging around in handbooks, etc., and as a result the use of a pipe is avoided. Or, a pipe much too large or too small is used, chosen entirely by "guess." The pipe that is too small may fail and be the cause of disaster. It is always best, of course, to be on the safe side, but at the same time one should practice economy.

To assist those who may have occasion to use standard pipes in this way and to make it as easy as possible for them, I have developed the following simple table and rules:

1. Knowing the load that is to be carried and the length of pipe needed, make a "guess," as to the size of pipe. Column A in the tables will help in making the guess as it gives the maximum length of pipe that may be used. Thus, never use a ⅛-in. pipe, as an important column, longer than 14.5 in. Never use a 3-in. pipe, as an important column, longer than 139 in., etc.

2. Multiply the length of the pipe in inches by the corresponding figure in Column B of the table. This

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product should never be greater than 12,000. If it is greater than 12,000, it means that you have guessed a pipe that is too small. After getting the right size, proceed as follows:

3. Subtract the product from 19,000. If the difference is equal to or less than 13,000 use it, in (4). If the difference is more than 13,000 use 13,000 in (4).

4. Multiply by the figure in Column C, corresponding with the pipe size.

The result is the number of pounds that the pipe will carry as a column, strut, or "push member." If the result is less than the load to be carried, try again, using the next larger pipe size, and so on until the proper and most economical size is selected.

Size of pipes, inches.	Column A Maximum length inches	Column B	Column C
⅛	14.5	826.4	0.07
¼	19.4	617.3	0.12
⅜	25.	480.8	0.17
½	31.3	383.1	0.25
¾	40.	300.3	0.33
1	50.6	237.5	0.50
1¼	64.7	185.5	0.67
1½	75.	160.5	0.80
2	94.7	126.9	1.07
2½	114.	105.3	1.71
3	139.	86.21	2.24
3½	161.	74.63	2.68
4	181.	66.23	3.18
4½	202.	59.52	3.68
5	226.	53.19	4.32

For example, it is desired to support a load of 10,000 lb. at a height of 84 in. What size of pipe should be used? Following the rules, we do this:

1. "Guessing" the size of pipe, Column A shows that 84 in. falls between 1½ and 2-in. pipe. We will therefore try a 2-in. pipe.

2. $84 \times 126.9 = 10{,}650$. This is less than 12,000 and we will therefore continue.

3. $19{,}000 - 10{,}650 = 8350$. This is less than 13,000 and we may therefore use it in (4). If the difference were 18,350, we would have to use 13,000 in (4).

4. $8350 \times 1.07 = 8950$ lb.

Since 8950 lb. is less than 10,000 lb. a 2-in. pipe is too small. We will therefore recalculate, this time trying a 2½-in. pipe.

2. $84 \times 105.3 = 8850$

3. $19{,}000 - 8850 = 10{,}150$

4. $10{,}150 \times 1.71 = 17{,}370$ lb.

This shows that a 2½-in. pipe would be amply safe to hold up 10,000 lb. It shows that a 2½-in. pipe is capable of holding almost twice as much as a 2-in. pipe at a height of 84 in. The small difference in pipe sizes and the great difference in strength indicates the necessity of careful computation and the danger involved in guesswork.

For the benefit of those who wish to check up the truthfulness of the foregoing rules, I will state that they are based upon the so-called "American Bridge Co. formula" which is

$$S = 19{,}000 - 100 \frac{l}{r}$$

Where S = permissible unit stress in lb. per sq. in., 13,000 lb. per sq. in. being the maximum.

l = length of column in inches;

r = radius of gyration in inches.

These factors are all simple enough for the average engineer who is accustomed to formulas, with the possible exception of the radius of gyration. It is always bothersome to the writer to have to look up formulas on radius of gyration and no doubt is so considered by others also. I have therefore compiled a table giving the radius of gyration of all standard pipe sections from ⅛ in. to 5 in. I do not find these tabulated in any handbook and therefore computed them from the formula for concentric sections such as a pipe section, namely,

$$r = \frac{\sqrt{D^2 + d^2}}{4}$$

The cross-sectional area of metal in standard pipes can be found in handbooks, but for the sake of completeness I am also giving areas in the table below. With these figures one can quickly compute or check any standard pipe column up to and including 5 in.

Size of pipe, inches	Outside diameter, inches	Inside diameter, inches	Radius of gyration	Cross sectional area square inches
⅛	0.405	0.27	0.121	0.07
¼	0.540	0.36	0.162	0.12
⅜	0.675	0.49	0.208	0.17
½	0.840	0.62	0.261	0.25
¾	1.05	0.82	0.333	0.33
1	1.315	1.05	0.421	0.50
1¼	1.66	1.38	0.539	0.67
1½	1.9	1.61	0.623	0.80
2	2.375	2.07	0.788	1.07
2½	2.875	2.47	0.95	1.71
3	3.5	3.07	1.16	2.24
3½	4	3.55	1.34	2.68
4	4.5	4.03	1.51	3.18
4½	5	4.51	1.68	3.68
5	5.563	5.05	1.88	4.32

For example, using the formula in place of the preceding rules and table and applying it to the same problem, it becomes necessary to "guess" just the same, formula or no formula, on account of the $\frac{l}{r}$ ratio (known as the "slenderness ratio") and on account of the nature of the formula and the condition that 13,000 lb. per sq. in. is the maximum allowable unit stress.

Just to check up the table and rules let us make a guess this time that a 2½-in. pipe will do the trick.

Then, our table shows that r for a 2½-in. pipe = 0.95 in. whence, substituting in the formula,

$$S = 19{,}000 - \frac{100 \times 84}{0.95} = 10{,}150 \text{ lb. per sq. in.}$$

This, it will be noted, is the same as the result given by "item 3" above.

Then, multiplying by the cross-sectional area of the pipe in square inches, which in this case is 1.71 sq. in., we get: $10{,}150 \times 1.71 = 17{,}370$ lb.

Power Plant Troubles

SUGGESTIONS FOR AVOIDING UNNECESSARY EXPENSE IN MAKING REPAIRS. BY H. A. JAHNKE

IT is an easy matter for an engineer in charge of a steam plant to incur unnecessary expense when making or having repairs made. I refer to the general repairs and upkeep of a steam plant. The engineer may have some part replaced that perhaps is but little worn, and which with a little care or proper adjustment would have given service for a long time.

To show how true this is, I relate the following: An engineer had trouble with the eccentric on his high-speed steam engine pounding badly and as the two eccentric straps were close together, there was no way of taking out the lost motion by adjusting the two bolts. As the straps were babbited, he made arrangements with a nearby machine shop to rebabbit them at the first opportunity when the engine would be idle. When this day arrived and a man was sent up from the shop, after the eccentric straps were removed from the eccentric it was found that there still was about 3/16 in. of babbit in the straps. The engineer ordered this babbit removed in order that the straps might be rebabbited, thus, providing a thicker lining to allow for taking up lost motion due to future wear.

The man doing the job suggested that in place of removing the old babbit lining, a better and cheaper plan would be to take from 1/8 to 3/16 in. off one of the eccentric straps where they joined together, thus allowing the lost motion to be taken up again. In doing this, it was found that a part of the strap would hit a pin which runs from the governor to the eccentric. To remedy the difficulty, this part of the strap was turned down as shown at A in Fig. 1, the same amount as was taken off the strap where they joined together, hence there was no trouble in this striking the pin as the babbit wore away.

In making this repair in this manner, it took only about half the time required to do it in accordance with the engineer's original plan. When it is taken into consideration that the babbit would have to be cut, a special mandrel made to rebabbit, the straps turned out and then fitted, the saving in time and money that was effected can be appreciated.

The engine runs noiselessly and as well as ever and the eccentric straps will give service for a number of years with the old babbit lining.

BORE OF CRANKPIN BOXES TOO LARGE

IN ANOTHER instance, an engineer caused unnecessary expense and delay of the plant, due to the fact the engineer either made a blunder or had but little experience in babbiting a bearing.

It was necessary to rebabbit the crankpin boxes on a large Corliss engine. After the boxes were removed from the pin and connecting rod, they were taken to a nearby machine shop where the work was to be done. In taking the boxes to the shop, the engineer gave the diameter of the crankpin and gave orders that the bore of the boxes should be made 1/32 in. larger than the diameter of the crankpin. The manager of the machine shop wanted to know for what reason the bore of the boxes should be larger than the pin, as this would cause trouble. But the engineer insisted that the bore should be made larger than the crankpin. His orders were carried out with the following results: After the boxes were babbited and replaced, and the engine was given a trial, it sounded as if a trip hammer was in operation in the engine room. No amount of adjusting of the boxes remedied the trouble for long and it was necessary to remove the boxes again to be rebabbited to fit the diameter of the pin, when there was no further trouble.

I believe the trouble was caused in the following way: As the bore of the boxes was 1/32 in. too large, they would only grip the pin at the two points A B as shown in Fig. 2, with the result that the boxes and rod

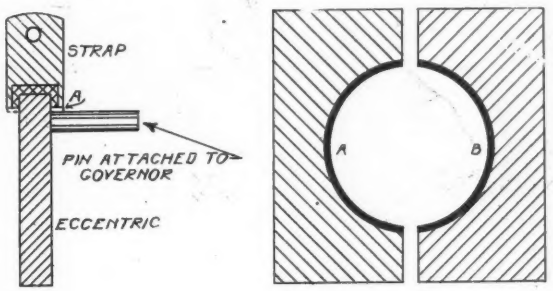


FIG 1 FIG. 2

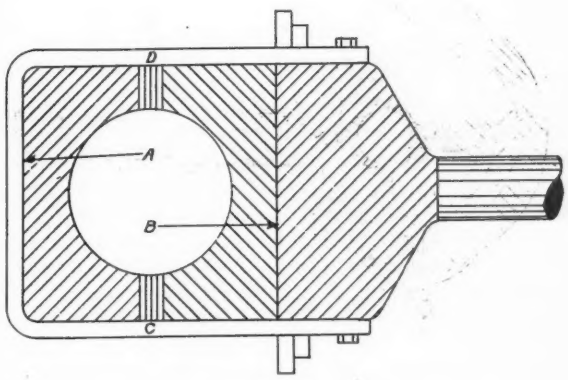


FIG. 3

FIG. 1. SECTIONAL VIEW THROUGH ECCENTRIC AND STRAP
FIG. 2. CRANKPIN BOXES
FIG. 3. SKETCH OF CONNECTING ROD END WITH KEY ADJUSTMENT

would lift and drop at each revolution of the engine. What reason the engineer had for having the bore of the boxes made larger, nobody knew. Was it, perhaps, that he thought there would not be so great a danger of the boxes heating as when they fitted the pin all around.

REMEDY FOR PREVENTING CRANK AND CROSSHEAD BOXES WEARING

ON ENGINES where the connecting rod end is of the type illustrated in Fig. 3, and lost motion is taken up by a key, the crankpin not only pounds be-

tween the two half boxes but the boxes also move between the strap and key at A and B, thus, not only wearing the boxes at these points, but also causing a knock. To prevent this trouble, whenever I had charge of an engine of this type, I shimmed up between the two half boxes, as shown at C, D, until the boxes had a good fit over the crankpin, then the key was driven down solid. This prevents any movement of the boxes between the points A and B and whenever necessary to adjust the boxes again one of the shims is removed and key driven down solid.

This trouble can also be avoided when it is not desirable to have shims between the boxes. To fit the boxes bring them close together as shown in Fig. 4 at A and B. Then whenever necessary to adjust the boxes again file off a certain amount of one of the boxes at the points A and B to take out the lost motion.

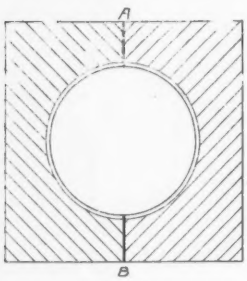


FIG. 4

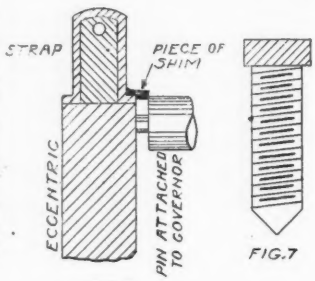


FIG. 6

FIG. 7

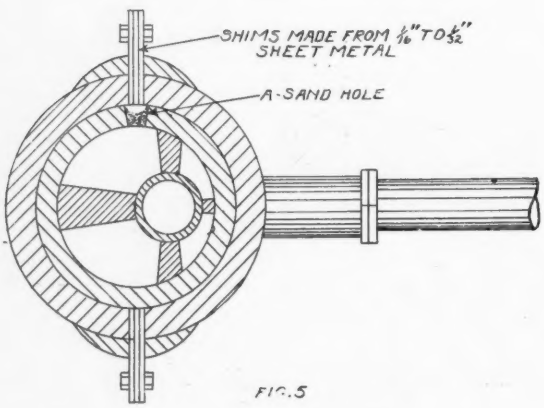


FIG. 5

FIG. 4. ILLUSTRATING METHOD OF TAKING UP LOST MOTION BY FILING

FIG. 5. SAND HOLE IN FACE OF ECCENTRIC AND SHIM CAUSES NOISE

FIG. 6. WIDE SHIM IN ECCENTRIC STRAP STRIKES PIN ON ECCENTRIC

FIG. 7. CENTER PUNCH MADE OUT OF A SET SCREW

Of course, in both ways care must be taken to adjust the boxes when fitting them over the pin so they will not bind the pin when the key is driven down solid.

Two Peculiar Eccentric Troubles

The eccentric straps on a high-speed steam engine were overhauled and adjusted to fit the eccentric, making it necessary to place shims between the two halves of the strap. After the engine was in operation again, a flopping noise was heard in the eccentric. At first it was thought that the straps were loose on the eccentric, so some of the shims were removed. After the engine was started, the noise still could be heard. This was puzzling, for the straps could not be adjusted any closer as they started to heat the way they were. Then the straps were disconnected from the eccentric. In doing this, I noticed that one of the shims was close to the eccentric working surface as shown at A in Fig. 5. Then I happened to think that there was a sand hole in the face of the eccentric, as illustrated, and I came to the conclusion that the loose shim and sand hole were the cause of the noise; so all the shims were adjusted to give a little clearance between them and the eccentric, after which the noise could not be heard. The trouble was evidently in the following way: The shim was very close to the eccentric surface and whenever the sand hole came under the shim this would in some way strike the edges of the sand hole and make the peculiar noise at each revolution of the engine.

In another instance, this same trouble occurred on another high-speed engine, but in another way, shortly after some repairs had been made on the eccentric straps. After the engine was in operation a flopping noise could be heard at each revolution of the engine. A number of adjustments were made to remedy the trouble, when finally it was found that one of the shims between the two eccentric straps was a little wider than the straps, causing it to strike a pin next to the eccentric and attached to the automatic governor. When the shim was cut off flush with the eccentric surface, the trouble was remedied. The cause is shown in Fig. 6.

Adjusting a Sight Feed Oil Cup

Where it is necessary to use a sight feed oil cup on an engine, it is quite hard to adjust this cup while the engine is in operation. I have found it to be a good plan to adjust the cup before it is placed on the bearing. This can be done by filling the cup with oil and clamping it in a vise, placing a can under the outlet of the cup. The cup can be adjusted so the oil in the cup will hold out for the number of hours desired. If after the cup is placed on the bearing, it is found that a little more or less feed is needed it can easily be secured by turning the needle valve one way or the other when the engine, or other apparatus to which the cup is attached is idle.

I have found this a much better plan for adjusting the cup than when it is placed on the bearing first, especially on an eccentric strap or some other fast-moving bearing on an engine where the oil in the cup must last for a number of hours before it can be filled again, hence there is danger of the bearing running dry, due to the fact that the cup is empty long before it is time to shut down the engine.

Making a Center Punch

At one time, I was in need of a very short center punch to make a center mark in some close quarters. As I had no steel on hand to make one, I decided to make one out of a short ⅜-in. hardened set screw as used in shaft collars. The end of this was ground down to a point as shown in Fig. 7. This did the work nicely.

Meeting Conditions as They Come

GENERALITIES ARE usually dangerous because they fail to deal with or cover properly all cases and conditions. Therefore, in speaking in generalities or talking of averages or providing for general conditions we take each by and large and govern our statements or our actions or fashion our product accordingly. The consequence is that while we fulfill the requirement in general, special or specific cases require specific and different products, acts or statements.

This holds true of guards for protecting moving parts and dangerous places from passersby, and those whose work brings them into close proximity to the location where the danger exists. The guard lessens or eradicates the danger, according to circumstances. The installation of guards, the aim sought and the way of meeting it follow a few almost self-evident rules or conditions. These may be called generalities. For example, a guard must be able to withstand the conditions that may be imposed upon it; it must not create, of itself, a hazard. It must not interfere with the work unduly nor restrict light. It should be of minimum cost compatible with producing safety, it should not increase the fire hazard and should permit of ready removal during times when it must be removed to execute repairs.

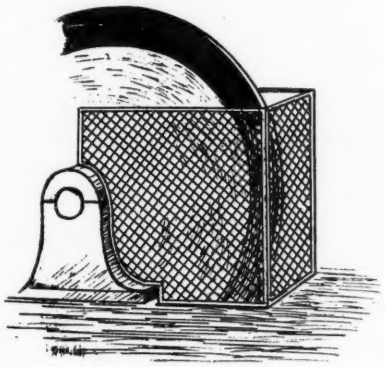


FIG. 1. NET WORK GUARD FOR FLYWHEEL

These are generalities that can be laid down. Something is always cropping up that, figuratively speaking, "throws the monkey wrench in the wheels." Sidney J. Williams, chief engineer, National Safety Council, in the Nov. 15 issue of Power Plant Engineering shows in Fig. 2, an illustration of a safe design for a flywheel railing or guard. Speaking in generalities, the guard or railing shown is safe, but the guard shown fails to meet all conditions. The truth is that there is, perhaps, though not necessarily, no such thing as an universal guard for flywheel pits that suffices for all conditions.

The guard shown by Mr. Williams is a guard 3½ ft. high with an intermediate rail halfway between the floor and the top rail. Such a railing prevents a man from slipping into the flywheel pit if he stumbles on the floor, faints, etc. If there is no toeboard, which Mr. Williams recommends, a man may slip and slide into the flywheel pit through the space between the floor and the intermediate rail 2 ft. above it. The railing shown usually is anchored to the floor, with the vertical rails close to the machine shaft. These vertical rails often leave a space at the pedestal to allow a man to climb up on the pedestal and examine the oil rings to see if they are revolving. Oil is often present at the pedestal. This space constitutes a danger because a man slipping on the oily floor may readily fall into the flywheel pit.

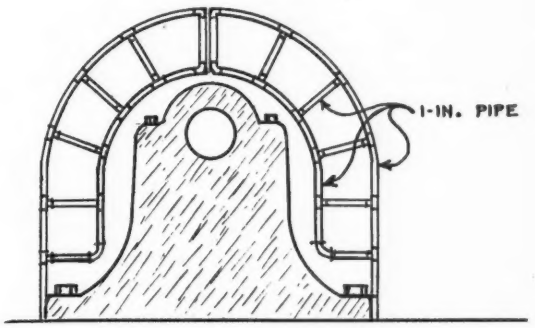


FIG. 2. PIPE GUARD OVER BEARING

This danger can be obviated by installing a wire guard around the shaft, and installing a ladder for the attendant to climb up the pedestal.

Recently a railing such as is shown in the Nov. 15 issue of Power Plant Engineering proved itself utterly useless. In consequence two men lost their lives. Here is a typical instance where the generality does not apply.

There were two reciprocating engines so located that the cylinders of the one engine were at right angles to those of the other engine and about 8 ft. from the flywheel. Both flywheels were protected by guards as shown in the issue referred to above. For some reason, the high-pressure cylinder head of the one engine blew off just at the time the two engine-room men were at the engine throttle. The force blew both men against the railing protecting the flywheel. The rail was either too low or the space between the horizontal rails was too great to serve the purpose and both men were hurled into the rotating flywheel. Both men were terribly mangled and both met instant death.

Had a guard of wire net existed instead of a railing with the sections 1½ ft. apart and 2 ft. from the floor with a total height of only 3½ ft. the men might have

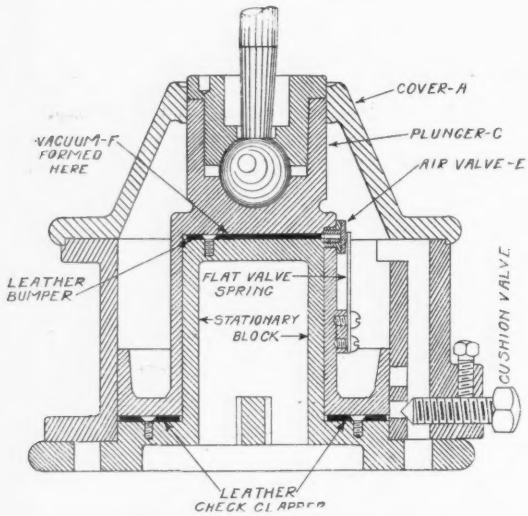
been killed by the impact. They would not have been mangled and hurled half across the engine room floor.

The question every engineer should ask himself is, "Do my safety devices protect against all possible conditions?" It is not good policy to have cramped engine rooms with engines placed longitudinally in two or three different directions. For many plants, as the one referred to above, a guard 6 ft. high and of net of 1-in. mesh is probably the type of guard indicated. This type of guard is particularly advantageous for around shafting as shown in the accompanying sketch.

K. RANKIN.

Dashpot Trouble

A DASHPOT that will not close the valve is, to say the least, a dangerous device. It does not become so serious on a single eccentric engine because it, having



SECTIONAL VIEW OF DASHPOT

more steam lap, would not be affected with slight hold-up as badly as a double eccentric having slight lap.

In starting up one day when the valves were lifting high, the steam valve would not drop and it became necessary for me to stand on the dashpot to make it close. Being a double eccentric it of course should knock off at about ¾ stroke while starting up, while on the safety pin, after speed was up, things were no better and the engine was running over speed because of this hold-up. To shut down was out of the question.

I lifted the cover A up a foot while the fireman held it and with a knife blade slipped under the air valve E I scraped around on its surface and the dashpot dropped in good shape and I put down the cover A, which is simply pressed down tight on the top of dashpot and it was all right for the rest of the afternoon.

I knew something must have caused this trouble, so at the first opportunity I took the dashpot out. The vacuum air valve on the side of plunger C is made like a cup over a baseball, the seat having four holes each the size of a darning needle. Valve E had worn so thin on the edge that it had a wire edge and could be picked off, and it was particles of this wire edge that got between the valve and seat when the dashpot was lifting and held valve E off its seat, which destroyed the vacuum in chamber F, hence no suction was had. With a knife I scraped the wire edge off and have had no trouble since.

Another thing might be of interest to someone in the case of pump lubrication. This particular boiler feed pump would groan. The best cylinder oil was given it almost in a steady fine stream; the lubricator gave it in drops as large as a rice kernel, but the drops followed each other closely so that a quart of cylinder oil was given each day and still it groaned.

I had another lubricator that gave a drop as large as a bean, so I put it on and while this did not give a drop 1/10 as often as the other lubricator, and at the end of the day used less than one-half the amount of oil, yet the groan ceased after it got the big drops. Just why this should be I can not explain, but it proved that large drops once in a while are better than twice as much oil in small drops. I don't know why.

A. C. WALDRON.

Repairing Holes in Metal-Lined Tanks

SOMETIMES even the practical man is perplexed when it comes to repairing holes in the upright part of wood, metal-lined tanks.

FIG. 1

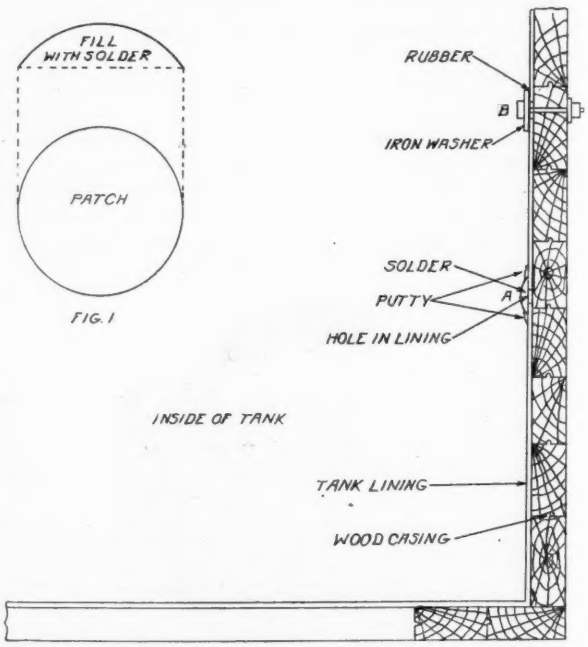


FIG. 2

FIG. 1. SHOWING METHOD OF FILLING PATCH WITH SOLDER
FIG. 2. METHOD OF APPLYING PATCHES TO INSIDE OF TANK

If the lining is galvanized iron, zinc, copper or lead, the following tips will help. Referring to Figs. 1 and 2, cut a sheet-metal patch at least 1 in. greater in diameter than the hole to be repaired; with the round end of a hammer, beat it into the shape shown in Fig. 1. Clean the inside of the patch and tin it. Clean around the hole in the tank lining and tin the cleaned part.

Fill the patch with solder and place it over the hole. Soften some putty and put it all around the edge of the patch. Next have the solder iron, or any iron, made

very hot and hold it against the patch at A, Fig. 2. This will melt the solder. The putty will prevent the solder running out. Remove the hot bar, allow the solder to cool and then remove the putty. Result, a really first class repair.

If the tank is in a situation where the outside is easily got at, a patch such as is shown at B, Fig. 2, might be used.

With the solder patch, however, it is quite as easy to repair a burst upright pipe of material such as lead, copper, or brass. JAMES E. NOBLE.

Diagram for Switchboard Operators

FOR INTELLIGENT operation of sub and power stations, the operator must know the position of every switch, both oil and disconnecting, at all times. He must also know just what is required of him when undertaking any switching.

With the modern switchboard with its mimic busses, the operator can, to a certain extent, see the entire layout, but confusion might occur if the station layout is complicated.

A small diagram placed on the operator's desk that would show all oil switches, lines, etc., and which would indicate the position, whether open or closed, is a good investment.

An ordinary schematic one-line station diagram placed under a thin sheet of glass and fastened to the operator's desk will answer the purpose.

The glass is spotted with red or green ink over the symbol representing the oil switch. It may be plainly seen; the ink dries and upon looking at the diagram, the symbol being spotted, the position may readily be observed.

Disconnects or disconnecting switches may be drawn; if open, a small spot of green ink over the symbol will indicate the fact. In event of tagging or placing hold cards, a dash of red beside the oil switch will answer very well.

It will be surprising to note how easy it is to write on the glass; this makes it possible to make remarks as to tags, etc. CLEMENT COREY.

Paint for Iron Stacks

FOLLOWING IS a recipe for an excellent paint for iron stacks. This paint lasts at least twice as long as any other we have used and looks well: 50 lb. finely powdered foundry graphite, 16 lb. white lead, 10 gal. boiled linseed oil, 1 lb. lampblack, 1 gal. japan.

This makes about 14 gal. and covers 2900 sq. ft. of surface one coat, which is equivalent to 205 or 210 sq. ft. per gal. The amount given in the recipe is the quantity required for two 50 in. by 80 ft. and one 42 in. by 70-ft. stacks. With us one painting of the outside of the stacks has kept them in good condition for 2 yr. I wish somebody would tell us how to keep the inside of these stacks in good condition.

When first cost and interest on the investment are taken in consideration there is not much difference in cost between an iron and brick stack, but the brick is by far the more satisfactory. We put up two steel stacks exactly alike in all ways except that one had a ladder riveted to it on the outside. The one with the ladder went to pieces and had to be replaced; the other one seems to be in very good shape, due no doubt to the temperature of the ladder not corresponding to the temperature of the stack, thereby throwing a strain (stress) on the sheets and pulling them apart at the laps when they became thin at this point.

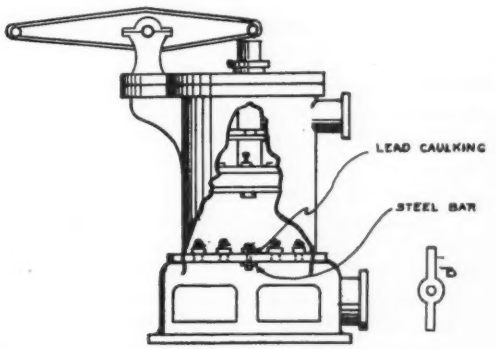
Some argue that the bottom of the courses should telescope inside at the ring laps; but I don't believe this would help much, because the vertical lap eats away about as fast as the circular, and sometimes when constructed this way they give way and telescope for a distance, and may buckle and throw the boilers out of commission all at once.

It is better to use two sets of guys and we favor placing the upper set close to the top; there does not seem to be so much bending action this way.

This is one of the objectionable features of a guyed stack having a lot of wires strung out over the landscape and buildings. J. O. BENEFIEL.

Repairs to Foot-Valves of Air Pumps

IN A STREET railway plant where I was employed, a beam air-pump was connected to the condensing main, and driven by a 100-hp. Corliss engine. There were eight 6-in. foot-valves, the seats being driven in the cast-iron plate, and caulked with lead, as shown in sketch. Considerable difficulty was experienced with the foot-valve seats pulling out of the plate. As many as three and four would pull out at one time.

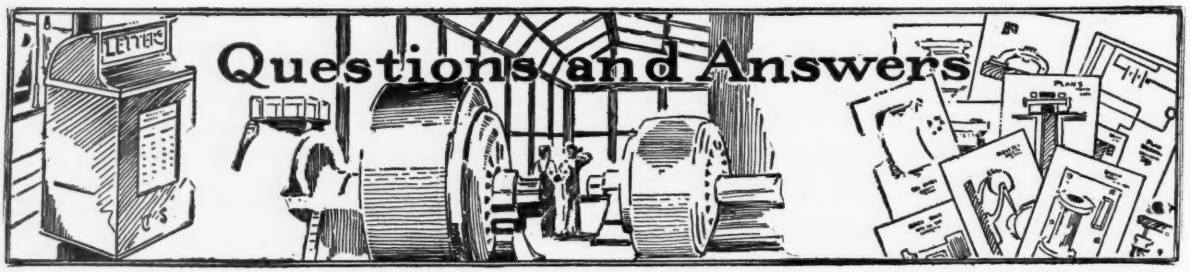


SECTION THROUGH AIR PUMP

Brass bars, 1 by ½-in. (the ½-in. was in the vertical section, in order to offer as little obstruction as possible to the passage of water) and longer valve studs were provided, to screw through the seats, and pass through the bars, with a nut on the bottom. We were much surprised to find the brass bars snapping in two, and the seats pulling out as before. A set of forged steel bars, like B, were then made (2 by ½-in.) and galvanized, and studs 1 in. longer were used, and after that, we had no more trouble.

This pump got its suction through about 100 ft. of horizontal pipe, with an average lift of 9 ft., depending on the tide. It had been noticed that the trouble generally occurred when the tide was low, or the strainer on the end of the pipe was clogged up.

M. M. BROWN.



Setting for Burning Fuel Oil

BURNING FUEL oil under our boiler with the setting shown in the accompanying diagram, we obtain an evaporation of approximately 10 lb. of water per pound of fuel. Feed water is 210 deg. F., pressure, 100 lb. gage, fuel is 24 deg. Bé., having a heating value of 19,000 B.t.u. per lb. This setting is in an ice plant where we produce 1.5 T. of ice per bbl. of fuel. The setting is perfectly airtight, boiler is clean and free of all scale.

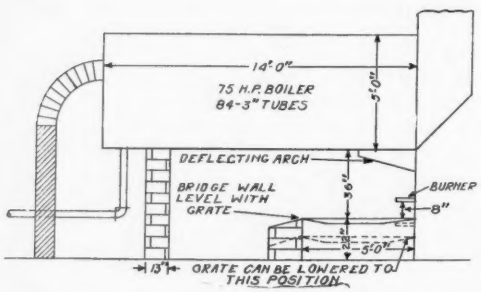


DIAGRAM OF SETTING AS ADAPTED FOR OIL

Would we be able to obtain better results by lowering the grate somewhat, say one foot? What else could be done to better the economy?

S. I. C.

Pump Becomes Air Bound

UNDER THE above title, H. W. T. describes in the Dec. 15 issue difficulty he is experiencing with a 4-in., two-stage motor driven centrifugal pump.

The data given is not complete for the purposes of analysis of the trouble, but from that given, we take the following:

Lift 13.5 ft., discharge head 187 ft., pipe line 1200 ft. of 6-in. diam. Flow 250 g.p.m., which is equivalent to about 3 ft. per sec., which is not excessive.

The total pumping head is pipe friction (estimated) 10 ft. plus suction lift, 13.5 plus discharge head, 187, equals 210.5 ft.

This is not severe duty for a two-stage pump and, as no suggestion is made of any motor trouble, assuming the pump is properly designed for the duty and that the motor is of suitable size and also that there is no obstruction in the pipe at any point.

It is my opinion that the entire trouble will be found in the suction pipe, and that a careful revision of it will remove all difficulty.

I would suggest that the present suction pipe be replaced with a new 6-in. line carefully laid so as to avoid any sags or high spots, beginning the line with a good, dependable foot valve and ending at the pump with a reducing elbow of the long radius pattern or a standard, flanged taper reducer, or if this must be installed in a horizontal position, use one of the eccentric pattern with the tapered side on the bottom.

The 4-in. suction inlet to the pump will give such a high velocity to the water as to make it desirable to make this portion as short as possible; it is also advisable to make the change in pipe size, and consequently, velocity of the water, as gradually as may be. The same is likewise true in increasing the size on the pump discharge in order that full advantage may be taken of the velocity of the water at this point.

Without definite knowledge of the arrangement of the piping, the following explanation may not fit the case in hand, but is, in principle, correct.

When carrying but 250 g.p.m., the flow in an 8-in. pipe is slow, only 1.6 ft. per sec., and any air entering the suction, whether entrained in the water or coming from slight leaks, could readily accumulate at any high point in the line or at the point where the pipe size is reduced, if the reduction occurred in a horizontal portion of the pipe and an eccentric fitting were not used; this would continue until a considerable quantity had accumulated, gradually shutting off the water and increasing its velocity at that point until, due to the rapid flow, a slug of air would be picked up and, on reaching the pump, reduce the amount of water entering. When enough to fill the pump inlet comes in one slug, the pump will drop its water.

In some pumps the design of the casing is such as to aggravate this action by reason of allowing an accumulation of air in the casing. In a case of this sort, especial care must be taken in avoiding leaks or air pockets.

A. L. EARNER.

PERHAPS THE pump, after having lost its suction, was allowed to run idle for some time, in hopes that during that period it might regain its suction. Instead air leaked through the packing gland into the suction line and the packing burned out for lack of lubrication. The pump should be stopped as soon as the suction is lost, so as to prevent such an occurrence.

As there are two reductions in pipe sizes in the suction line, from 8 to 4 in., there is likelihood of air pockets being formed at the reduction fittings unless they are the eccentric type with the straight side on top.

In case the foot valve on the suction line leaks, water will flow back to the source when the pump is stopped if there is the slightest leak in the line. Care should be taken to see that this valve is in proper working

condition and that the line is air tight throughout its length. PATRICK MOLLOY.

IF THE pump is unable to deliver its full capacity the fault may be laid to belt slippage, if the pump is belt driven. A belt of insufficient width will lie down in this way under overloads. The condition may be corrected by using a wider belt, or by installing a silent chain drive. The cost of such a change would be easily paid for in a short time.

Air binding of the pump may be caused by leakage into the suction line through open joints or pit holes. This condition is preventable and should be remedied as soon as possible. A poorly mounted pump will be subject to severe vibration which will be communicated to the piping, and will open up the joints, permitting air infiltration. Such a condition should not be tolerated and the pump should be put on a solid concrete foundation. It might be caused by dissolved air in the water. As this condition cannot usually be prevented, provision should be made for getting rid of the air at the pump casing. By placing the pump as near to the highest water level as possible, the evils of high lift may be effectively mitigated. H. W. ROSE.

WROUGHT IRON or steel pipe is subject to rusting under unfavorable conditions which will open up in the joints through which air may enter and cause air binding. If the line is underground, enough water will leak out during idle periods to saturate the soil in the vicinity of the leak and thus form an air seal which will enable the pump to run without air binding for a short while.

If the foot valve on the suction line is tight, the line may be tested for leakage by filling it with water, while the pump is idle, and noting the time required for the level to fall a given amount. The time required is inversely proportional to the amount of leakage. The pump casing and stuffing boxes may also be tested in this way.

The fact that the packing wears out rapidly would seem to indicate that a better grade could be used to advantage to prevent air leakage at the stuffing box. This fact might also indicate that the journal had settled in its bearing, becoming out of line with the gland. In this case re-babbiting the bearings would remedy the trouble. The gland and water may be gritty, which would chew up the packing rapidly. Only pure water should be used for this purpose. R. A. CULTRA.

Lightning Arrester on Short Overhead Line

I NOTE in the Dec. 1 issue an inquiry from C. S. C. requesting an opinion regarding the installation of lightning arresters on a short overhead line supplying three-phase power to a couple of large size motors.

I am of the opinion that if I were the chief engineer in charge of the installation I would promptly order 12 low voltage alternating current wall type lightning arresters and install one at every point where a wire enters or leaves the building. Then and only then would I feel easy in my mind. Lightning is capable of some curious effects. A heavy stroke occurring anywhere within a hundred yards and parallel to the circuit is quite liable to induce a momentary electromotive force in these wires sufficient to break down the installation in the stators of the motors or possibly of the generator, thus grounding the machine. The consequent current which would follow the ground might burn out a coil.

I have in mind an experience in Providence, Ky., in the summer of 1918, where I was called to assist in getting a generator, which had been struck by lightning, back in service. Four sections of the armature were badly burned. This machine was an engine type 250-v., direct current generator. The power house was about 30 ft. from the mouth of the shaft of a coal mine. The wires ran from the generator switchboard through the wall of the engine room, jumped to the side of the tipple, and then passed directly down the shaft from which the current was distributed to various cutting machines about 300 ft. below. The actual length of the aerial line was about 30 ft., and it was suspended about 12 ft. from the ground. What actually happened was that a heavy stroke of lightning passed probably in a horizontal direction between two clouds, directly above, and probably not over 200 ft. from the ground. The induced electromotive force generated, by the high frequency of the lightning in the generator circuit, punctured the insulation and the current of the machine following the flash caused the burnout.

If you have a 500 and a 750-hp. motor on the end of an exposed line of only a few feet in length, I certainly would equip the line with lightning arresters and be on the safe side. A dozen lightning arresters cost a great deal less than one burnout.

LOCKE ETHERIDGE.

Twisted Valve Stems

IN THE December 1 issue, page 1167, appeared an article by T. S. K. concerning twisted valve stems on Corliss engine valves. This happens principally through a slug of water carried to the cylinder with the steam; it frequently happens when starting up an engine and while the engine is turning around slowly and getting heated for starting time. Sometimes the engineer forgets to open the drainpipe valve connected on the throttle valve for draining the condensation; then, again, if the stop valves on the boiler are not closed when the plant is shut down, the steam on the lines between the engines and boiler will condense overnight, especially in cold weather, even if the lines are insulated. If the lines are not properly graded, water pockets will be formed and those condensation pockets cannot be drained out by the drain at the throttle valve; but if there is a steam separator, it will help immensely provided the steam trap connected to the separator to remove the condensation is working in good condition. This trap should get strict attention while the engines are running in any case while admitting a small amount of steam to allow the engine to turn slowly.

One morning a slug of water came along with the steam which twisted one of the exhaust valve stems. I could hear the sound of the slug very plainly as I was standing close by the engine. Steam commenced to blow past the valve through the post. As the valve would not close in this type of valve movement, I had to lengthen the arm on the valve stem in order to keep

the plant running for the whole day. I then took the valve out, had the stem forged and straightened out in a lathe, put it back in place and was ready to start next morning. PATRICK MOLLOY.

What Causes Leaky Tubes

IN THE November 15 issue of Power Plant Engineering, a question was asked as to what caused the flues to leak in two 72-in. by 16-ft. return tubular boilers.

I was called on a case of trouble of the same kind several years ago.

Four boilers set as illustrated in Fig. 1 were giving trouble in a contractor's plant where coal was burned. Steam jets in the stacks made the rates of combustion high. They had been unable to keep the flues tight in the backheads since the plant was started about 6 mo. before.

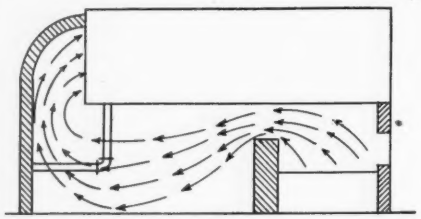


FIG.1

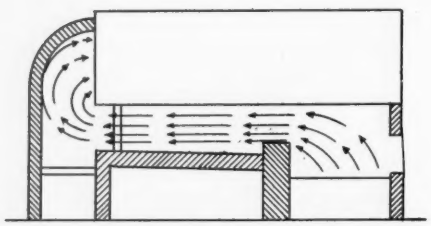


FIG.2

FIG. 1. ORIGINAL BOILER SETTING

FIG. 2. COMBUSTION CHAMBER FILLED WITH ASHES AND PAVED

After looking the boilers over, I reached the conclusion that there was too much space in the combustion chamber back of the bridge wall, and the gases were not following the shell, but were sweeping the bottom of the chamber, and most of the heat was given up on the back head and in the rear end of the flues. So much heat was concentrated there that the water would not stay in contact with the plate.

The combustion chamber was filled with ashes and paved with common brick as in Fig. 2.

After the flues were rolled, no further trouble was experienced in over a year. Also less coal was burned doing the same work. C. G. HARDEN.

Cause of Tube Distortion

THE LETTER from D. T. McA. in the Dec. 15 issue carries me back to a subject on which I have wondered much.

This distortion, while I have never seen such a thing in boiler tubing, is, I am sure, quite similar to a like behavior sometimes observed in automobile inner-tubes. The latter phenomenon is no doubt familiar to those readers who drive cars.

The inner-tube is an old one, which has been in use for a long time. It has probably been inflated and deflated a number of times, and in this process, as well as while the car was in motion, it has been rubbed thin against the casing; one place has been worn especially thin. At length something occurs which renders it necessary to remove the tube from the casing. While it is out the tube is pumped up with air to a considerable pressure, so that any possible leaks may be located. Then it is noted that an enlargement occurs at the thin place, ending in, or possibly culminating at the center in a bulge similar to the one described. The wonder is that the tube, having stretched, and so become thinner, does not burst, but it seldom does.

The boiler tube in question has been in use for 8½ years, so it must have been cleaned a great many times. At some time when it was undergoing this process, it was damaged, making a rough place (or the rough place might have been caused by corrosion). Successive cleanings have enlarged this rough place, and also thinned the tube perceptibly.

At last there came a time when for some reason this section of the tube was subjected to an unusual strain. The steel tube acted the same as the rubber one, and stretched. Why it did not burst is inexplicable. We only know the facts. Unlike the rubber tube, however, it did not return to its original shape when the pressure was released, as it was too stiff.

GEO. F. SWETNAM

SUCH BAGGING has occurred in tubes where there was only a slight scale accumulation, seemingly in quantities insufficient to cause the trouble. The tubes affected were generally in the middle of the header and the bag, in the first pass where the heat is much more intense.

One bag, that I know of, occurred in the tube where it passed through the first baffle. One of the bricks adjacent to this tube had been displaced, leaving a hole through the wall. With forced firing, the heat imparted to the tube by the gases, which were being short-circuited through this hole, was more than could be absorbed by the water, through the tube and about 3/32 in. of scale. As a consequence, the tube was overheated and burned. Due to the lowering of the tensile strength as the temperature increased, the tube expanded at this point, under the boiler pressure. At the same moment however, the scale formation broke and allowed water to come in contact with the metal cooling it and thus preventing further distortion and rupture. The loosened scale was carried away by the water circulation and thus the bulge appeared clean on examination.

Owing to the fact that the tube in question had been in service for 8½ yr. and had probably been cleaned a number of times, one is led to believe that an initial strain may have been imposed on the distorted section when cleaning. When this tube was replaced in service, scale accumulated faster at this section with the result that local overheat occurred and distortion followed.

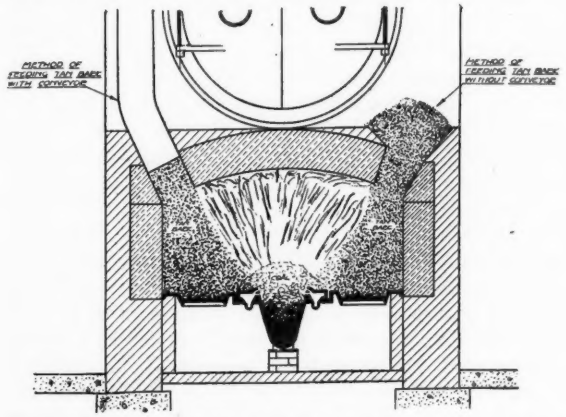
R. A. CULTRA.

WATER POWER development is being pushed in New Zealand by both private and government enterprise. Projects are under way for developing or enlarging 28 plants, the total increase in capacity amounting to 190,000 hp.

Wood Burning Stoker

ANSWERING THE question by N. P. in the Dec. 1 issue on wood burning stoker, would state that there are many installations of under-feed stokers burning wood refuse with a small quantity of coal in connection with boilers of the size and type mentioned.

The under-feed stoker eliminates the necessity of carrying a heavy draft inside the furnace. The wood shavings, sawdust and small blocks are generally fed into the top of the Dutch oven, and larger pieces may be thrown into the side doors. When a large amount of refuse is available, only enough coal is used to protect the grates, or when the supply of refuse fails for any reason, the coal feed may be immediately speeded up, the forced draft increased, and the steam pressure maintained.



ARRANGEMENT OF FURNACE FOR BURNING HOGGED WASTE

The accompanying figure illustrates a typical application of under-feed stoker for burning refuse. In order to secure good combustion, the Dutch oven should be of ample size, the bridge wall fairly low and refuse fed in evenly. F. A. DE BOOS.

IN REPLY to the request from N. P. in the Dec. 1 issue, I would like to say that we have had the same trouble with our hog fuel feeding system which we eliminated by cutting away the upper portion of the supply pipe, making it a kind of trough. By this arrangement, the possibility of clogging the pipe is remote and any residual air pressure occasioned by the separator is readily dissipated.

The heavy down drafts which N. P. experiences may be eliminated by employing a larger cyclone separator.

L. S. FARWELL, JR.

Which Water Should Be Used?

AFTER observing the boiler trouble experienced by F. P. P., page 1024, Oct. 15 issue, I am just a little bit curious to know whether these conditions have always existed or not. Where water is considered suitable for feed water in boilers regardless of whether it produces no scale, a soft or hard scale has no bearing whatsoever upon the question of foaming. It is true indeed that it is at all times best to secure a feed water which will produce either a soft scale or no scale at all than a water that will produce a hard scale, as hard scales are costly to remove, and dangerous also.

In this case, however, this foaming could be due to overloaded boilers or too much water being carried in them, water columns set at too high a level or, possibly, the boilers are not equipped with steam domes and the steam pipe is connected directly into the top of the boilers without any dry pans or dry pipes inside of the boiler, and under these conditions they naturally will pick up some water. Where dry pans are used in some boilers they are simply made of sheet iron like an ordinary bread-baking pan perforated with half-inch holes or smaller, and bolted so as to fit directly under the outlet of the steam pipe.

The writer's general practice when confronted with a problem of this nature is to screw the pipe from the outside of the boiler with twice the ordinary length of thread on it so that you could, on the inside of the boiler, screw a T, allowing on each end of the T for about 3 ft. of the same size pipe screwed into it thoroughly perforated with ½-in. holes or smaller and caps on the ends of the nipples. This method not only will greatly assist in the drying of the steam, but will prevent water to a considerable extent from getting into the steam lines.

Too small steam main lines will cause this trouble also. In steam boilers of certain designs of the return tubular type it has been found that the circulation was too great, and this trouble has been eliminated by either entirely plugging up the two center rows of tubes from top to bottom in each row by the use of rods run through them, and cast-iron plates on each end of the tube screwed up by nuts, or by taking the tubes out altogether, plugging up the holes and reinforcing that part of the boiler with stay bolts running through the boiler. So in this case with the information at hand to determine positively what was the cause of this trouble, more mechanical information is necessary. A water producing a soft scale or hard scale has no bearing upon the foaming of boilers. H. W. ROSE.

Insulation Efficiency

CAN YOU supply me with the information necessary to calculate the amount of fuel or steam saved by the use of pipe covering? D. F. P.

A. The information available as to the amount of heat saved by insulating, shows a wide variation in results, but the following will probably answer for average conditions.

It is assumed that a bare pipe will radiate about 3 B.t.u. per sq. ft. per deg. difference in temperature between the steam and the surrounding air, per hour. This decreases with an increase in pipe diameter. If now we apply a covering to this pipe which will transmit only a half B.t.u. per sq. ft. per deg. per hr., the efficiency of this covering would be $(3 - 0.5) \div 3 = 83.3$ per cent.

The efficiency of various insulating materials is given approximately by Harding and Willard in the following table:

Asbestocel	76.8
Gast's air cell	74.4
Asbesto sponge felt	85.0
Magnesia	83.5
Asbesto sponge hair	86.0
Asbestos fire felt	73.5

These efficiencies are all based on a 1-in. thickness. They increase with an increase in internal temperature and also with the pipe size.

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Automatic Power Plants

To eliminate as far as possible all the weakness of human operatives from the regular operation of machinery has been a trend in the development of power plant equipment as well as in practically all other lines of mechanical and electrical engineering. We have merely to step back a few years in our memory to recall when practically the only automatic device in the power plant was the governor on the engine to maintain a more or less constant speed. The first successful stokers are scarcely more than a generation old and their automatic control to vary combustion in accordance with the demand for steam has reached a practical degree of perfection only during the past few years. Nevertheless we are approaching a perfection in power plant design which calls for the minimum of attention in regular operation, by the development of automatic starting, stopping and controlling devices.

While it should never be expected that a steam power plant can be operated without constant attendance, automatic devices are becoming so reliable that small gasoline engine and hydraulic driven generating plants are now in successful operation without any attention for days at a time.

It is only natural to expect that out of the small farm lighting plants will grow larger and more important plants driven by oil engines and supplying electricity for light and power in isolated villages or industrial establishments, completely automatic so far as starting, stopping and voltage control are concerned. Such a development has been made possible largely through the perfection of automatic service restoring short circuit interrupters and automatic sectionalizing equipment such as is used for railway feeder circuits.

Automatic hydroelectric generating stations present a means of collecting the power now being wasted in many small streams and feeding it into a distributing system which has other sources of reliable supply. Heretofore such small power plants were not economical, due largely to the cost of operation as an attendant was required constantly on duty. During the past year, a 150-kw. hydroelectric generating station with complete automatic control has been put into operation which probably will be followed by many more of even larger capacity.

Great advance has also been made in the design of electric substations to the extent that now many of these are automatic in operation requiring attention at intervals of about a week to insure the proper conditions of commutators and bearings. Such stations are in use at steel mills, mines, industrial plants, or three-wire systems and on electric railway systems of cities as well as for interurban service.

Another recent development which will undoubtedly broaden the scope of automatic operation and make it more efficient is an automatic starting device for synchronous motors.

All of this development points directly to the fact that the men who hold responsible positions in modern power plants must familiarize themselves with the principles of operation and details of construction of all power plant equipment. They must know how to make adjustments of controlling devices and what conditions will give highest efficiency and how they can be maintained.

We must get away from the idea, too prevalent today, that power plant operation is a matter of routine work consisting principally of starting and stopping which in future will be done largely by automatic devices, and view the power plant as a laboratory in which chemical and mechanical changes are taking place with scientific exactness, the variations of which must be carefully noted, their causes determined and correction made to obtain highest efficiency. The power plant engineer must be capable of performing a service no machine or combination of machines can do.

Heat Balance

Power plant equipment is gradually reaching a state of development such that further improvements will only result in comparatively small gains as far as efficiency is concerned. During the past decade, the obtainable efficiencies of turbines, pumps, boilers, generators and other equipment have been raised, due to continued improvements, until today we find ourselves approaching the maximum. Of course, we do not wish to go on record as having made the assertion that modern equipment has reached the limit of perfection or the limit of efficiency; but with present type equipment, further increases in efficiency of individual machines can only be obtained by the most refined developments. We fully realize that the introduction of some radically new principle in place of principles now employed may, in certain cases, result in marked improvements. Labor saving methods and devices have also been introduced in the power plant to such an extent that the cost of fuel is, today, by far the greatest item of expense in generating power.

Confronted with this state of affairs, our next move towards bringing about a reduction in operating costs is to select and group the various pieces of apparatus which go to make up the power plant in such a manner as to increase the overall efficiency of the combination. In other words, we must correlate the events in the heat cycle of the plant as a whole, so as to adjust the rate of steam generation to the demand with the least possible waste of heat. This is termed heat balance.

In any plant where the highest economy is desired, the method of operating the auxiliaries must be carefully considered, as an appreciable savings can be effected by employing the correct method. When steam driven auxiliaries are used and the exhaust from these machines is used for heating the feed water in condensing plants, it is difficult or practically impossible so to regulate the supply of exhaust steam that it will be just sufficient to heat the feed water and no more. The rate at which the auxiliaries run is practically constant, while the amount of feed water to be heated varies with the load.

Considered from a thermo-dynamic viewpoint, steam driven auxiliaries are justified, wherever their exhaust can be condensed, in heating boiler feed water. The thermal efficiency of the condensing engine or turbine is at best only about 20 per cent. Eighty per cent of the heat supplied to it in steam is rejected in the circulating water. If we neglect the losses due to radiation and leakage, all the heat not converted into mechanical power by the steam driven auxiliary whose exhaust is used in heating the feed water, is returned to the boiler.

The saving due to the use of steam driven auxiliaries is therefore apparent. If, however, when the load is light the amount of auxiliary exhaust exceeds the amount needed to heat the feed water, it might be more economical to employ a certain number of electrically driven auxiliaries. Or, if an excess amount of exhaust is available, it may be utilized in the main turbine by introducing it into the lower stages.

On the other hand, to avoid feeding cold water to the boiler during periods of heavy load, low pressure steam can be taken from one of the intermediate stages of the main unit and used to heat the feed water.

There are a number of combinations, each of which possesses advantages. The correct solution for a particular plant, however, is dependent upon local conditions. In certain industrial plants, for instance, where an abundance of exhaust steam from factory processes is available, the problem will be entirely different from that presented in a public utility plant.

The article on the subject of heat balance appearing in the current issue, although dealing primarily with systems employed in large stations, may contain ideas on this subject which might also be applied to the smaller plant, and from this viewpoint should be of considerable interest to designers and operators of such plants.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

What's What*

By Dr. Frank Crane

THE great question is not Who's Who, but What's What. Who's Who sounds too much like an owl, and there's about as much sense to it. What's What concerns a man's ability. Only one thing puts your name on the What's What list—making good. What's What is a matter of doing something.

The What's Whatters raise the food, make the clothes, sell the goods, run the railroads, drive the rivets, fell the trees, dig the coal, pound the iron, tame the horses, construct the automobiles, sweep the floors, cook the food, tend the babies and watch and wait and work for mankind.

The What's Whatters stand flat on their own feet; so they do not seem as tall as the Who's Whoers, who ride upon other folks' shoulders.

What's What is doing the world's work, fighting the world's battles, solving the world's grim problems.

*Copyright, 1921, by Dr. Frank Crane.

Yearly Index

The Index for Volume XXV of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

Refractory Concrete Baffles

THE importance of tight boiler baffles that will stand up under forced firing and will not develop cracks and leaks with extreme temperature variations is fully recognized. Losses due to faulty baffle design and construction often constitute a considerable percentage of the total B.t.u. loss in evaporation. Tight baffles insure increased steaming capacity and fuel saving.

Concrete baffles using Hytempite, high temperature cement, to bond the aggregate were installed at the plant of the Queens Borough Gas & Electric Co. over 3 yr. ago. In tearing out the boiler settings for the purpose of installing larger boilers an opportunity was given to examine the condition of the baffles, which were in as good shape as the day they were poured.

The same method and materials were used in pouring baffles for the new boilers, as shown in the accompanying illustrations. Wood forms—pine, spruce or cypress preferred—are assembled in accordance with the sketch, Fig. 5, in the following manner:

FIG. 1. PLACING SLATS BETWEEN TUBES IN PREPARATION FOR POURING CONCRETE BAFFLES
FIG. 2. FORMS FOR BAFFLES IN PLACE
FIG. 3. FORMS BLOCKED OFF READY FOR POURING
FIG. 4. POURING AND RAMMING OPERATION

Two 2 by 4-in. stringers or nailing pieces are placed parallel on top of the tubes centering on the proposed baffle. They should be of sufficient length to take care of blocking off piece or extension if it is desired to carry baffle into boiler walls. Two more stringers are placed under the row of tubes which mark the bottom of the proposed baffle. The position of these stringers depends on what angle the baffle shall take with relation to the tubes.

Slats 1 by 2½ in. are then placed diagonally between tubes, see Fig. 1, and nailed securely to stringers at top and bottom. Where these strips cross one another the lattice should be reinforced, so as to give a smooth inside surface. The forms will then appear as in Fig. 2. Blocking off pieces are nailed on as in Fig. 3 or extensions made as desired.

Mixture

HYTEMPITE is diluted with water in a cement or mortar box placed on the floor in a convenient spot. Enough water is added so that when worked smooth the mortar will have the consistency of a pancake batter.

To this batter Carbosand is gradually added, using care to see that all parts are thoroughly mixed. The

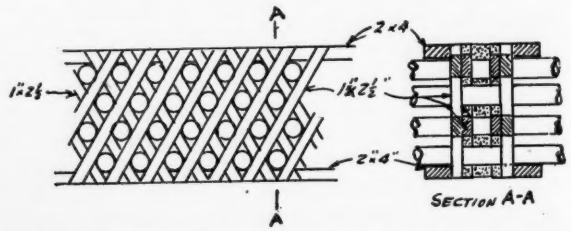


FIG. 5. LATTICE WORK FORM USED FOR CONCRETE BAFFLES

mixture should be a little more moist than moulding sand. Using a pail of this mixture at a time, enough water is added to each pail to permit pouring, but no more water than is absolutely necessary. Too thin a mixture will work out through the lattice.

Pouring and Ramming

A MAN with a good light is stationed under the tubes near the bridge wall to direct the pour. Two men on top of the tubes pour and ram the baffle, one of them working a thin strip up and down at the point of pouring to prevent the formation of pockets or voids.

Figure 4 shows the pouring and ramming operation; the legs and hands of the man ramming the mixture can just be seen. The use of Hytempite bonds the aggregate to form a solid one-piece baffle of refractory concrete. The wood form is burnt off when fires are lighted.

No trouble has been experienced when withdrawing tubes and inserting new ones when necessary. If the baffle is slightly fractured, repairs are made by mixing Hytempite with water to the consistency of mortar and applying the mixture to the broken part by means of a long strip of wood.

The construction of the new as well as the old baffles was carried out under the supervision of the Quigley Furnace Specialties Co., 26 Cortlandt St., New York.

New Renewable Fuse

AFTER several years spent in perfecting a renewable fuse the Cote Bros. Mfg. Corp., of Chicago, has placed on the market a socket fuse of the Edison type and renewable for use on circuits of 125 v. with ratings from 3 to 30 amp. The fuse as shown in the figures consists of three parts, the body, the cap and the refill. The cap and body are of heat resisting molded insulation, and are built in generous proportions.

The refill is a little cartridge, properly vented for the emission of the gases when the element vaporizes,

and has the rating of this element stamped on both ends so that it is always visible through the aperture in the cap, regardless of how it is inserted in the body. The cost of this refill is very low.

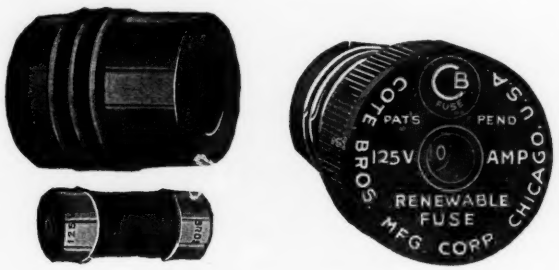


FIG. 1. THICK-WALLED BODY OF FUSE
FIG. 2. SMALL REFILL OF THE FUSE
FIG. 3. FUSE ASSEMBLED READY FOR INSERTION IN SOCKET

The main feature of this fuse is the ease with which it is renewed. The refilling consists of merely dropping the cartridge into the cup-like body and screwing down the cap. When so assembled, there are no live parts of the plug exposed. This also leaves the rating visible at all times.

Pulverized Fuel for Small Plants

BECAUSE the demand for a unit which would open the savings of powdered fuel firing to the small plant as well as provide a compact unit for the larger installation, there has been developed, recently, the Pulverburner. This unit, which has been put

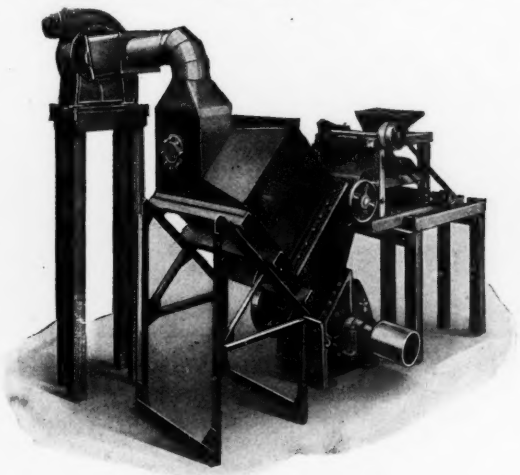


FIG. 1. PHOTOGRAPH OF PULVERBURNER SHOWING UNIT CONSTRUCTION

on the market by the K-B Pulverizer Co., Inc., consists of a patented pulverizing machine and air separating chamber automatically fed from an overhead storage bin, and delivering the powdered fuel by fan blast through suitable piping to the combustion chamber. There is no auxiliary equipment.

Coal fed to the pulverizer, at any desired rate of speed, is crushed by rapidly revolving hammers against breaking blocks, and is thrown by centrifugal force into the separating chamber. Air, drawn through the chamber at low velocity (by the fan), carries away the fine coal and allows the coarse coal to return to the machine for further pulverization. The fine coal is drawn

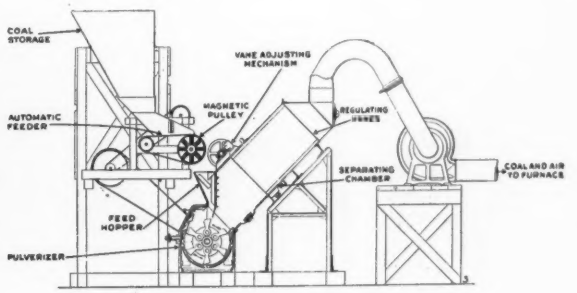


FIG. 2. DIAGRAM OF THE PULVERBURNER

through the fan and delivered directly to the nozzle, or can be divided into several streams to serve several nozzles.

Steel-Belt Conveyors

WHEN a belt conveyor is mentioned, it is natural for the engineer to picture in his mind a canvas, balata, or rubber belt, because of their universal adoption. To speak of a steel belt conveyor immediately brings one into a foreign field and questions arise because of the fact that they have not been used in this country.

About 12 yr. ago the Sandviken Steel Works in Sweden began to make steel belt to be used for convey-

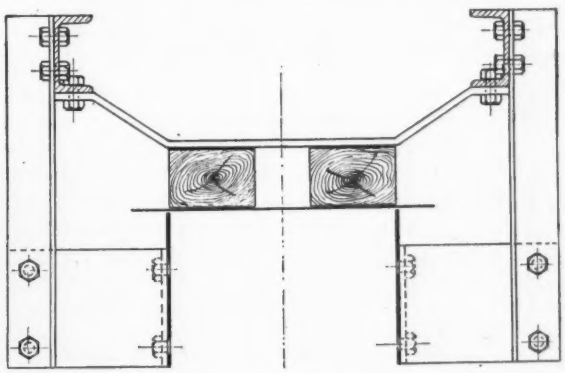


FIG. 1. STEEL-BELT CONVEYOR WITH SKIRT BOARDS

ing purposes in the various phases of industry where it has met with decided success. To date about 1300 installations have been made, handling materials of all kinds.

The Sandvik belt is operated at 28,000 to 30,000 lb. per sq. in. stress when traveling over the pulley. It has a hard, dense surface, which resists rust, abrasion and heat, but it should be coated with a rust preventive when standing idle for a considerable time. Because of rigidity and freedom from vibration the steel belt can be loaded for ⅔ its width, running flat. It is unloaded for part or all of its width by spring steel ploughs which can be set at any point on its length.

The belting is now made in lengths up to 300 ft. for width of 16 in., thickness 0.035 in. It may be in-

stalled to slide on modern timbers, with or without skirt boards to form a trough as in Fig. 1, or may be carried on rollers. In either case, the return run is carried on idlers. The first named method is used for light and non-abrasive material; the second is preferred for heavy loads and abrasives, the edges being left free. Steel belting cannot be troughed.

FIG. 2. STEEL-BELT CARRYING CRUSHED COAL AT 14 DEG. INCLINE

Inclined runs may be used up to 14 to 20 deg., according to the material handled. For steeper runs, strips or angle chips are riveted to the center part of the belt, but delivery is then only possible over terminal drums.

General Utility Hoist

TO PROVIDE an electric hoist for every load-moving job, small as well as large, is the purpose of the Liftabout, a small general utility hoist recently announced by the Shepard Electric Crane and Hoist Co., Montour Falls, N. Y. This hoist is particularly designed and suited not only to usual lifting jobs encountered in factories, mills and warehouses, but also for the more specialized jobs wherever hand labor is now employed for carrying and putting down.

In use the hoist is most versatile, for it can be operated wherever electric current is available and is easily installed on the side of a building, on the ceiling of a basement, or in any point that will bear the weight of a load.

A BILL has been introduced in the Senate to supplement the act for construction of a bridge across the Hudson River at New York.

Million Volt Transformer for Experimental Laboratory

THE 1000-kv.a., 1,000,000-v. transformer being built by the Westinghouse Electric & Manufacturing Co. for the experimental laboratory at Trafford City, Pa., is assuming its final shape. The photographs show its relative size, but they do not indicate the immensity of such a transformer. There are nearly 70 mi. of wire in the windings. The transformer is built on the principle of distributing electrostatic stress as developed by C. L. Fortescue 7 or 8 yr. ago.

The terminal bushing is the largest ever built in the Westinghouse shops. Special machines had to be fitted to turn the bushing on this account. Its length is 19 ft.

SHOWING CONSTRUCTION OF MILLION VOLT TRANSFORMER

and it is 41½ in. in diameter. The static shield will be 10 ft. in diameter and 20 in. deep. The bushing will weigh about 9000 lb. when completed.

IN NORTHERN France, steam plants are being constructed at the coal mines to use unsalable fuel and supply current to a network supplying the industrial districts. Details of the projects can be obtained from the Bureau of Foreign and Domestic Commerce, Washington, D. C., by asking for File No. Elec. 10.

ITALY HAS in view the development of a hydraulic works on the River Sila by means of impounding reservoirs with capacity of 250,000,000 cu. yd. The plants will be three in number with capacity of 168,267 hp. and yearly output of 800,000,000 kw.-hr.

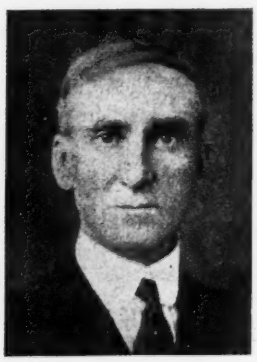
Dexter S. Kimball

PRESIDENT, AMERICAN SOCIETY OF MECHANICAL ENGINEERS; DEAN OF THE COLLEGE OF ENGINEERING, CORNELL UNIVERSITY

DEAN KIMBALL is first of all a broad-minded, big-hearted man. Besides, he is a living example of what can be accomplished, when one has common sense, kindliness, ambition to help and achieve, and an unlimited capacity for work.

Certainly his start 56 yr. ago in the little town of New River, New Brunswick, on the Bay of Fundy, would not be considered as unusual favors from Fortune; nor did his start at the age of 16 yr. as an apprentice in Pope and Talbot Iron Works, Port Gamble, Washington, to which state his family had removed, give outlook for a path of roses. But Kimball was not looking for roses then, and has never sought the easy way at any time since.

After a few years he went with the Union Iron Works, in San Francisco, but realizing that he was handicapped, he took up studies in Stanford University and by the time he was 30 achieved a bachelor's degree in engineering, in 1896, and in 1913 Stanford awarded him the degree of M. E. After serving a short time on



DEXTER SIMPSON KIMBALL

the engineering staff of the Anaconda Mining Co., he was called to an assistant professorship of machine design in Sibley College of Cornell in 1898 where he remained 3 yr., until he was offered the position as works manager of the Stanley Mfg. Co., Pittsfield, Mass.

Cornell discovered her mistake in letting Mr. Kimball get away, however, and in 1904 recalled him as professor of machine design and construction and has had the good fortune to keep him on the faculty ever since. In 1915 he became professor of industrial engineering, in 1918 he was acting president of the university and in 1920 was made dean of the reorganized College of Engineering, which now includes all the engineering schools.

One would think this a fairly busy program, but not so. Since 1911 Dean Kimball has been active on the Council of Industrial Engineering of the New York State Dept. of Education; he has always been ready to respond to calls to address gatherings of alumni, with whom he is a favorite and to whom he always brings a worth while message. He has written several books, as co-author with John H. Barr, Elements of Machine Design, and independently, Industrial Education, Principles of Industrial Organization, Elements of Cost Finding, and Plant Management.

Also reading of books both light and heavy and study of his profession are part of his life; he can tell a story so that you really chuckle—no courtesy laugh—he is good company on a trip or of an evening, and you always find that he has given you something to think about afterwards.

Yet he keeps himself in shape, can always tackle a little more work, if he thinks it should be done, and even Mrs. Kimball has never known him to lose his temper. He never seems exhausted; even the trying days of the S. A. T. C. period at Cornell, 1917 to 1920, did not overcome him. But his secret may be the houseboat on Lake Cayuga, where he and the family go for rest at such times as his busy life permits.

Dean Kimball believes that the engineer should take his place in the world of affairs, as well as directing construction and development. He says that students should learn not only the fundamentals of engineering, but enough of other subjects to give them a proper idea of the relation of their profession to the world's activities, and their own relation to their fellow-men. And he puts this belief into practice. He is active in the Society for Promotion of Engineering Education, in the Society of Industrial Engineers, is a vice-president of the Federated American Engineering Societies, and president of the American Society of Mechanical Engineers.

To those fortunate enough to know him, Dean Kimball is a dear friend and a delightful companion; an ideal of what a live, earnest, useful engineer should be; but above all a real man, interested in serving his fellowmen, his community and his nation.

News Notes

THE FEDERAL SUPPLY CO., Cleveland, Ohio, has been appointed representative in that territory for the Quigley Furnace Specialties Co., Inc., New York City.

COMBUSTION ENGINEERING CORPORATION has opened a new branch office in the First National Bank Building, Pittsburgh, Pa. This office will be in charge of W. C. Stripe, formerly of the Philadelphia office.

THE IDEAL COMMUTATOR DRESSER CO., Chicago, announces the establishment of district sales offices in New York City, at 154 Nassau Street. R. W. Becker is in charge.

THE EXETER MACHINE WORKS, Inc., of West Pittston, Pa., announces the appointment of J. E. Holveck as district sales representative in the Pittsburgh district. Mr. Holveck was until recently connected with Crawford & Cameron, of Pittsburgh, and was formerly designing engineer for the Aldrich Pump Co.

WORK HAS been started at the plant of the Westinghouse Electric & Manufacturing Co. on electrical transformers for the Daido Electric Power Co. of Japan. The contract calls for 34 transformers, averaging 9400 kv.a. each, single-phase, 60-cycle, oil-insulated and

water-cooled, and will have a high voltage of 154,000 v. When installed, they will weight 50 T. each.

These transformers will be used in a super-power system in the industrial district about Tokio, similar to that now under construction for the area between Boston and Washington. One of the Japanese stations, planned for Furukawabashi, will contain 18 transformers with a total output of 169,200 kv.a.; another at Ohi will have nine transformers with a total output of 82,800 kv.a., and a third at Suhara will be equipped with seven transformers with a total output of 64,400 kv.a.

THE GREEN ENGINEERING CO., East Chicago, Ind., announces the opening of a direct branch sales office in Suite 941 Monadnock Building, 53 W. Jackson Boulevard, Chicago. The former agency representation has been discontinued in the Chicago District. The change was made in order to maintain better service and closer relations with the company's business friends in the district. J. W. Himmelsbach has been appointed district manager with supervision over sales in Northern Illinois, Northern Indiana, Iowa and Michigan. P. Albert Poppenhusen, president of the company, will maintain an office at the Chicago address. The general sales office will remain at the factory.

A DEPARTMENT of Agricultural Engineering has recently been organized at the Virginia Polytechnic Institute, Blacksburg, Va. (State Agricultural College), and a 4-yr. course in agricultural engineering will be started in September, 1922. This department is interested in getting catalogs and other descriptive matter from all companies manufacturing farm equipment.

Books and Catalogs

THE MEASUREMENT OF STEADY AND FLUCTUATING TEMPERATURES; HEAT TRANSMISSION BY RADIATION, CONDUCTION AND CONVECTION; HEAT TRANSMISSION IN BOILERS, CONDENSERS AND EVAPORATORS; by R. R. Royds; size 5½ by 8½, cloth, 162, 238, and 302 pages respectively; New York, N. Y., 1921.

These three books form a consecutive series on the general subject of heat. The first book is intended to give a concise account of modern methods of measuring both steady and fluctuating temperatures and to indicate their applications in industrial practice. The use and limits of use of the mercury thermometer is discussed and the measurement of temperatures, impossible or impractical for the fluid thermometer, by electrical thermometers and pyrometers, by radiation and optical pyrometers is carefully treated. The subject of the accurate and instantaneous measurement of rapidly fluctuating temperatures is treated in detail.

The book on the three methods of heat transmissions discusses some technical experiments on heat transmission by radiation, convection and conduction; the results obtained and the conclusions drawn. The results illustrate the laws of heat flow, but because of the fact that the experiments were conducted on a small scale, they can not fairly be considered directly applicable to large boilers or heaters without further investigation.

The treatise on heat transmission in boilers, condensers and evaporators takes up this further investigation. Experiments were conducted on full size apparatus over a wide range of rating under what would correspond to operating conditions. Although the work is most comprehensive, no claim is made that the various experimental data lead to absolutely conclusive results under all conditions.

IN 1919 THERE was published by the Engineering Experiment Station of the University of Illinois a bulletin, No. 111, dealing with the forms in which sulphur occurs in coal. The research work in connection therewith was conducted in the Chemical Laboratory of the University of Illinois by S. W. Parr and A. R. Powell, who developed successful methods for determining quantitatively the different chemical forms of sulphur in coal.

Bulletin No. 125, by H. F. Yancey and Thomas Fraser, just issued by the Engineering Experiment Station, deals with the manner of occurrence and the distribution of the various forms of sulphur in the coal bed. The experimental work was undertaken as a part of the United States Bureau of Mines plan of research on coal preparation, and the application of the information secured to the problem of producing cleaner coal was the principal objective. The solution of this problem must of necessity rest to a considerable extent upon an intelligent knowledge and appreciation of the physical and the chemical forms in which sulphur occurs in a particular coal, and how it is distributed through the coal in the bed.

Copies of this Bulletin No. 125 may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

FRANCKE flexible couplings for direct-connected machines are illustrated and described in Bulletin No. 32 lately received from Smith & Serrell, Newark, N. J., general sales agents for The Francke Co.

A NEW BULLETIN, E-12, published by the M. J. Dougherty Co., Philadelphia, Pa., has interesting comments on the importance of the piping system and the value of proper design and erection. In brief concise language easily understood by anyone, it gives the busy executive a comprehensive outline of the essentials of modern piping practice.

CATALOG L of the Illinois Stoker Co., Alton, Ill., is handsomely printed and gives an analysis of the advantages of chain grates, and the economy to be obtained by sectional air control. Full description is given of type G stokers, with illustration of installations and details of drives and arches for various types of boilers, showing furnace dimensions for the latest ideas in boiler settings.

ALLIS-CHALMERS MFG. CO. has recently published two bulletins—No. 139, "Power Equipment for Textile Mills," and No. 1108, "Power Transformers." The first, devoted largely to illustrations, shows various applications of motor drives to picking, cording, spinning, winding and weaving machines. One section takes up prime movers of the hydraulic, steam turbine, and internal combustion engine types.

The second bulletin illustrates various types of power transformers used in present-day practice for long distance, high potential power transmission.